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The 12 Annual Meeting on the U. S. Army Corps of Engineers Aquatic Plant Control Research Program was held in New Orleans, La., on 3-7 October 1977 to review current operations activities and to afford an opportunity for presentation of current research projects.

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PREFACE

The 12th Annual Meeting of the U. S. Army Corps of Engineers Aquatic Plant Control Research Program was held at the Grand Hotel, New Orleans, Louisiana, on 3-6 October 1977. The meeting was organized by personnel of the Aquatic Plant Research Branch (APRB), Environmental Systems Division (ESD), Mobility and Environmental Systems Laboratory (MESL), U. S. Army Engineer Waterways Experiment Station (WES). The APRB is now part of the recently organized Environmental Laboratory (EL) of which Dr. John Harrison is Chief.

The organizational activities were carried out and presentations by WES personnel were prepared under the general supervision of Messrs. W. G. Shockley, Chief, MESL, and B. O. Benn, Chief, ESD, and under the direct supervision of Mr. J. L. Decell, Chief, APRB. Mr. W. N. Rushing, APRB, was responsible for planning and chairing the meeting.

COL John L. Cannon, CE, was Commander and Director of the WES at the time of this meeting and during the preparation of the proceedings report. Mr. F. R. Brown was Technical Director.

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ATTENDEES

12th ANNUAL MEETING
U. S. ARMY CORPS OF ENGINEERS
AQUATIC PLANT CONTROL RESEARCH PROGRAM

Grand Hotel
New Orleans, Louisiana

3-6 October 1977

Mr. E. E. Addor	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
1LT Claudia M. Akroyd	HQDA (DAEN-CWO-R) Washington, D. C. 20314
Dr. Clifford C. Amundsen	University of Tennessee Ecology Program Knoxville, TN 77843
Dr. Wendell Arnold	Elanco Products Company Florida Research Station Boynton Beach, FL 33435
Dr. Larry O. Bagnall	University of Florida Agricultural Engineering Department Gainesville, FL 32611
Mr. John W. Barko	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
Dr. J. Robert Barry	University of Southwestern Louisiana College of Agriculture Lafayette, LA 70501
Mr. John M. Bateman	Orange County Pollution Control Dept. 2008 E. Michigan Ave. Orlando, FL 32601
Mr. A. Leon Bates	Tennessee Valley Authority Water Quality & Ecology Branch Muscle Shoals, AL 35660
Mr. Bob O. Benn	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180

Dr. Arthur R. Benton, Jr.	Texas A&M University Remote Sensing Center College Station, TX 77843
Mr. Leslie E. Bitting, Sr.	Old Plantation Water Control District 8800 N. New River Canal Road Plantation, FL 33324
Mr. Bob Blakeley	Old Plantation Water Control District 7049 NW 4th Street Plantation, FL 33317
Mr. Eldon C. Blancher	University of Florida Department of Environmental Engineering Gainesville, FL 32601
Mr. Richard K. Blush	USA Engineer District, Vicksburg P. O. Box 60 Vicksburg, MS 39180
Mr. Thomas O. Blythe	Sandoz, Inc. Rt. 2, Box 249 K Senatobia, MS 38668
Dr. Leonce Bonnefil	Commonwealth of Puerto Rico Department of Natural Resources P. O. Box 5887 Puerto de Tierra, Puerto Rico 00906
Mr. Marshall Brown	Pump It, Inc. P. O. Box 9515 Winter Haven, FL 33880
Mr. C. Brate Bryant	Aquamarine Corporation P. O. Box 616 Waukesha, WI 53186
Dr. Alva P. Burkhalter	Florida Department of Natural Resources 305 Blount Street Tallahassee, FL 32304
Mr. M. Douglas Carlson	Eli Lilly Company Zionsville, IN 46077
Mr. John L. Carothers	USA Engineer District, Charleston P. O. Box 919 Charleston, SC 29402

Mr. John Carroll	USA Engineer District, Tulsa P. O. Box 61 Tulsa, OK 74102
Mr. Roy P. Clark	U. S. Environmental Protection Agency 1421 Peachtree Street, N.E. Atlanta, GA 30309
Mr. R. W. Colby	Dow Chemical Company Midland, MI 48640
Mr. Henry A. Collins	CIBA-GEIGY Corporation P. O. Box 11422 Greensboro, NC 27409
Mr. Roger Conley	University of Florida Dept. of Environmental Engineering Gainesville, FL 32601
Dr. Richard Couch	Oral Roberts University 7777 S. Lewis Tulsa, OK 74102
Dr. Thomas Crisman	University of Florida Department of Environmental Engineering Gainesville, FL 32601
Mr. Moody M. Culpepper	(formerly of USAE Waterways Experiment Station) USA Engineer District, Vicksburg P. O. Box 60 Vicksburg, MS 39180
LTC Phillip E. Custer	Panama Canal Company Drawer M Balboa Heights, Canal Zone
Mr. Warren A. Davis	Amchem Products, Inc. Brookside Ave. Ambler, PA 19002
Mr. J. Lewis Decell	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
Mr. Don Duffy	U. S. Environmental Protection Agency Washington, D. C.
Mr. Michael J. Eubanks	USA Engineer District, Mobile P. O. Box 2288 Mobile, AL 36628

Ms. Katherine C. Ewel	University of Florida School of Forest Resources and Conservation Gainesville, FL 32611
Mr. Chuck Feerick	University of Florida Department of Environmental Engineering Gainesville, FL 32601
Mr. William Fleming	USA Engineer District, Memphis 668 Clifford Davis Federal Building Memphis, TN 38103
Mr. Thomas Fontaine	University of Florida Department of Environmental Engineering Gainesville, FL 32601
Dr. J. A. Foret	University of Southwestern Louisiana College of Agriculture Lafayette, LA 70501
Mr. Mickey Fountain	USA Engineer District, Savannah P. O. Box 889 Savannah, GA 31402
Dr. Peter A. Frank	USDA-Science & Education Administration (formerly ARS) University of California Botany Department Davis, CA 95616
Dr. T. E. Freeman	University of Florida Department of Plant Pathology Gainesville, FL 32601
Mr. Rodney Fries	Lantana Boatyard 808 North Dixie Highway Lantana, Florida 33460
Mr. Johnnie Frizzell	Pennwalt Corp. P. O. Box 9129 Prattville, AL 36067
Mr. Clyde P. Gates	USA Engineer District, Little Rock P. O. Box 867 Little Rock, AR 72203
Mr. A. K. Gholson, Jr.	USA Engineer District, Mobile Lake Seminole P. O. Box 96 Chattahoochee, FL 32324

Mr. Terry Goldsby	Tennessee Valley Authority Water Quality & Ecology Branch Muscle Shoals, AL 35660
Mr. Eddie C. Gordon	Clarendon, Arkansas 72029
Mr. Lawrence B. Gordon	USA Engineer Division, Lower Miss. Valley P. O. Box 80 Vicksburg, MS 39180
Mr. M. J. Griffith	USA Engineer District, Seattle P. O. Box C-3755 Seattle, WA 98124
Mr. Howard Grisham	Kiwanis Club of Astor Rt. 1, Box 102 Astor, FL 32002
Mr. L. V. Guerra	Texas Parks & Wildlife Department 134 Braniff San Antonio, TX 78216
Mr. H. Roger Hamilton	HQDA (DAEN-CWO-R) Washington, D. C. 20314
Mr. Charles Hargrove	Rhodia Inc. 311 Raven Rock Lane Longwood, FL 32750
Dr. Frank W. Harris	Wright State University Department of Chemistry Dayton, OH 44231
Mr. Stanley L. Harrison	Amchem Products, Inc. Ambler, PA 19002
Mr. Dave Haumersen	USA Engineer District, St. Paul 1135 USPO & Custom House St. Paul, MN 55101
Mr. Scott Henderson	Arkansas Game & Fish Commission Joe Hogan State Fish Hatchery P.O. Box 178 Lonoke, AR 72806
Mr. James H. Hodge	USA Engineer District, Louisville P. O. Box 59 Louisville, KY 40201

Mr. William D. Hogan	Chevron Chemical R&D P. O. Box 160 Ocoee, FL 32761
Ms. Janice Hughes	Louisiana Dept. Wildlife & Fisheries P. O. Box 4004 Monroe, LA 71201
Mr. C. W. Hummer	Panama Canal Company Dredging Division Drawer O Gamboa, Canal Zone
Mr. John R. Inabinet	South Carolina Department of Health and Environmental Control 2600 Bull Street Columbia, SC 29201
Mr. John D. Ingraham	Nalco Chemical Company Western Springs, IL 60558
Mr. George A. Janes	Creative Biology Laboratory, Inc. 3070 Cleveland-Massillon Rd. Barberton, Ohio 44203
Mr. J. C. Joyce	USA Engineer District, Jacksonville P. O. Box 4970 Jacksonville, FL 32201
Mr. Thomas G. Kelpin	(formerly of Carver Aquatics) Allied Aquatics 9751 Linwood Avenue Shreveport, LA 71106
Mr. James G. Kennedy	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
Mr. Del Kidd	USA Engineer Division, New England 424 Trapelo Rd. Waltham, MA 02154
Dr. Richard Koegel	University of Wisconsin Department of Mechanical Engineering Madison, WI 53715
Mr. Floor Kooijman	University of Florida Department of Environmental Engineering Gainesville, FL 32601

Mr. Dennis H. Lade	Eli Lilly Company Indianapolis, IN
Mr. Bob Lancashire	Pump It, Inc. P. O. Box 9515 Winter Haven, FL 33880
Mr. Roy Land	Florida Game and Fresh Water Fish Commission 620 S. Meridian St. Tallahassee, FL 32304
Dr. L. W. Larson	USDA-Science & Education Administration (formerly ARS) P. O. Box 14565 Gainesville, FL 32604
Mr. Carlton R. Layne	U. S. Environmental Protection Agency Federal Bldg, Rm B2 124 South Tennessee Ave. Lakeland, FL 33081
Mr. Malcolm L. Leatherman	Louisiana Dept. of Wildlife & Fisheries Opelousas, LA 70570
Mr. Donald V. Lee	Louisiana Dept. of Wildlife & Fisheries P. O. Box 14526 Baton Rouge, LA 70808
Dr. L. E. Link	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
Mr. James Manning	Louisiana Dept. of Wildlife & Fisheries P. O. Box 14526 Baton Rouge, LA 70808
Mr. Chester O. Martin	USA Engineer District, Galveston P. O. Box 1229 Galveston, TX 77553
Mr. Loren M. Mason	USA Engineer District, Tulsa P. O. Box 61 Tulsa, OK 74102
Dr. Charles McCormick	University of Southern Mississippi Department of Polymer Science Box 470 Southern Station Hattiesburg, MS 39401

Mr. Max C. McCowen	Lilly Research Laboratories P. O. Box 708 Greenfield, IN 46140
Mr. Larry E. McCullough	South Carolina Department of Health and Environmental Control 2600 Bull Street Columbia, SC 29201
Dr. Roy McDiarmid	University of South Florida Department of Biology Tampa, FL 33620
Mr. Walton McDonald	Brandon, MS 39042
Mr. James T. McGehee	USA Engineer District, Jacksonville P. O. Box 4970 Jacksonville, FL 32201
Mr. Harry McGill	General Development Corp. P. O. Box 2507 Port Charlotte, FL 33952
Mr. Emory McKeithen	Amchem Products, Inc. P. O. Box 12100 Jackson, MS 39211
Mr. Woodard W. Miley, II	Florida Department of Natural Resources 305 Blount Street Tallahassee, FL 32304
Mr. Tom Minter	Amchem Products, Inc. Oviedo, FL 32765
Mr. Glen Montz	USA Engineer District, New Orleans P. O. Box 60267 New Orleans, LA 70160
Mr. Edward Moyer	USA Engineer District, Ft. Worth P. O. Box 17300 Ft. Worth, TX 76102
Mr. W. R. Mullison	Dow Chemical Midland, MI 48640
Mr. William T. Nailon	USA Engineer Division, Southwestern Main Tower Building 1200 Main Street Dallas, TX 75202

Mr. Larry E. Nall	Florida Department of Natural Resources 6810 Seminole Dr. Orlando, FL 32809
Mr. John H. Neil	Limnos Ltd. 22 Roe Ave. Toronto, Ontario, Canada M5M 2H7
Mr. R. J. Newton	Texas A&M University College Station, TX 77840
Mr. Edward Pack	Syracuse Research Corporation Merrill Lane, University Heights Syracuse, NY 13210
Mr. Stanley Parka	Lilly Research Laboratories P.O. Box 708 Greenfield, IN 46140
Dr. B. David Perkins	USDA-Science & Education Administration (formerly ARS) 3205 SW 70th Ave. Ft. Lauderdale, FL 33314
Mr. Clayton L. Phillippy	Florida Game & Fresh Water Fish Comm. 620 S. Meridian Street Tallahassee, FL 32304
Mr. Doug Powell	Pennwalt Corporation P. O. Box 9129 Prattville, AL 36067
Dr. P. C. Quimby, Jr.	USDA-Science & Education Administration (formerly ARS) Southern Weed Science Laboratory Stoneville, MS 38776
Mr. Julian J. Raynes	USA Engineer Division, South Atlantic 510 Title Building 30 Pryor Street, SW Atlanta, GA 30303
Mr. Louie V. Richardson	Louisiana Dept. of Wildlife & Fisheries P. O. Box 278 Tioga, LA 71477
Mr. Howard B. Roach	South Carolina Public Service Authority 223 N. Live Oak Dr. Moncks Corner, SC 29461

Mr. William N. Rushing	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
Mr. Harold T. Sansing	USA Engineer District, Nashville P. O. Box 1070 Nashville, TN 37202
Dr. Dana R. Sanders, Sr.	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
Mr. Nick Sassic	Orange County Pollution Control Dept. 2008 E. Michigan Avenue Orlando, FL 32601
Mr. K. E. Savage	USDA-Science & Education Administration (formerly ARS) Southern Weed Science Laboratory Stoneville, MS 38776
Mr. Woodland G. Shockley	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
Mr. James R. Skaggs	USA Engineer District, Tulsa P. O. Box 61 Tulsa, OK 74102
Mr. Perry A. Smith	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
Dr. Kerry K. Steward	USDA-Science & Education Administration (formerly ARS) 3205 SW 70th Avenue Ft. Lauderdale, FL 33314
Mr. Edwin A. Theriot	University of Southwest Louisiana Department of Microbiology Lafayette, LA 70504
Mr. Russell F. Theriot	USAE Waterways Experiment Station P. O. Box 631 Vicksburg, MS 39180
Mr. William E. Thompson	USA Engineer District, New Orleans P. O. Box 60267 New Orleans, LA 70160

Mr. Hector A. Toscani	Instituto National de Technilogico Agropecuaria Paraná River Region Argentina, South America
Mr. Nelson Virden	Virden Weed Control Service Rt. 3, Box 414 Jackson, MS 39213
Mr. Forest Ware	Florida Game & Fresh Water Fish Comm. 620 S. Meridian Street Tallahassee, FL 32304
Mr. Mac Watson	South Carolina Wildlife Resources Dept. P. O. Box 167 Columbia, SC 29202
Mr. George E. Wortley	Nalco Chemical Company 800 Sweetwater Blvd. Longwood, FL 32750

AGENDA

12th ANNUAL MEETING
U. S. ARMY CORPS OF ENGINEERS
AQUATIC PLANT CONTROL RESEARCH PROGRAM

Grand Hotel
New Orleans, Louisiana

3-6 October 1977

Monday, 3 October 1977

10:00 a.m. to 6:00 p.m.	Registration - Terrace Foyer, 6th Floor

Tuesday, 4 October 1977

8:30 a.m.	Registration Continues - Terrace Foyer
9:00 a.m.	Welcome - COL E. J. Rush, District Engineer, New Orleans
9:15 a.m.	Announcements and General Remarks - W. N. Rushing, Waterways Experiment Station
9:20 a.m.	The Corps of Engineers' Aquatic Plant Control Program - H. R. Hamilton, Office, Chief of Engineers, Washington, D. C.
9:45 a.m.	Break
10:00 a.m.	Keynote Address - Mr. Donald V. Lee, President, Aquatic Plant Management Society, Inc.
10:40 a.m.	The Management Plan Concept and Its Application for the Future for Corps of Engineers Aquatic Plant Control - J. L. Decell, Waterways Experiment Station
11:00 a.m.	Administration of Corps Aquatic Plant Control Program Budget (Corps of Engineers personnel only) - 1LT Claudia Akroyd, Office, Chief of Engineers, Washington, D. C.
11:30 a.m.	Lunch
1:00 p.m.	Panel - Corps of Engineers District Office Aquatic Plant Operations and Management Moderator: J. C. Joyce, Corps of Engineers District, Jacksonville

Chester Martin, Galveston District
W. E. Thompson, New Orleans District
Ed Moyer, Fort Worth District
M. J. Griffith, Seattle District
Mike Eubanks, Mobile District
Jim McGehee, Jacksonville District
John Carothers, Charleston District
Clyde Gates, Little Rock District
John Carroll, Tulsa District

3:00 p.m. Panel Summary, J. C. Joyce

3:15 p.m. Break

3:30 p.m. Panel - Aquatic Plant Problem Identification and Assessment
Moderator: J. L. Decell, Waterways Experiment Station

L. E. Link, Waterways Experiment Station
B. O. Benn, Waterways Experiment Station
A. R. Benton, Texas A&M University

4:30 p.m. Panel Summary, J. L. Decell

4:45 p.m. Summary of the day's program - B. O. Benn, Waterways Experiment Station

5:00 p.m. Adjourn for the Day

6:30 p.m. Dinner - Cabaret Room

<u>Wednesday, 5 October 1977</u>

8:30 a.m. Panel - Eurasian Watermilfoil Research and Control
Moderator: D. R. Sanders, Waterways Experiment Station

Clifford Amundsen, University of Tennessee
A. Leon Bates, Tennessee Valley Authority
Terry Goldsby, Tennessee Valley Authority
Loren M. Mason, Corps of Engineers District, Tulsa

9:45 a.m. Break

10:15 a.m. Panel Summary, D. R. Sanders

10:30 a.m.	Panel - Hydrilla Research and Control Moderator: Alva Burkhalter, Florida Department of Natural Resources L. V. Guerra, Texas Parks and Wildlife Department Donald V. Lee, Louisiana Wildlife and Fisheries Commission LTC Phillip E. Custer, Panama Canal Company Nick Sassic, Orange County Florida Pollution Control Department Les Bitting, Old Plantation Water Control District Doug Powell, Pennwalt representative Charles Hargrove, Rhodia representative George E. Wortley, Nalco representative
11:45 a.m.	Panel Summary, Alva Burkhalter
12:00 Noon	Lunch
1:30 p.m.	Field Trip to NASA's National Space Technology Laboratory, visit waterhyacinth sewage treatment research project--tour guide, Mr. B. C. Wolverton

Thursday, 6 October 1977

8:30 a.m.	Panel - Chemical Control Technology Development - Conventional, Controlled-Release, and Registration Moderator: Roy P. Clark, U. S. Environmental Protection Agency Carlton R. Layne, U. S. Environmental Protection Agency Donald Duffy, U. S. Environmental Protection Agency Kerry K. Steward, USDA Agricultural Research Service Edward Pack, Syracuse Research Corporation W. D. Hogan, Chevron Chemical Company Warren Davis, Amchem Products, Inc. Frank W. Harris, Wright State University George A. Janes, Creative Biology Laboratory J. Robert Barry, University of Southwestern Louisiana Charles McCormick, University of Southern Mississippi John Ingraham, Nalco Chemical Company L. V. Guerra, Texas Parks and Wildlife Department
9:45 a.m.	Break
10:00 a.m.	Panel Summary, Roy P. Clark

10:15 a.m. Panel - Biological Control Technology Development - Insects, Fish, Plant Pathogens, and Integrated Control

Moderator: T. E. Freeman, University of Florida

B. David Perkins, USDA Agricultural Research Service
Leonce Bonnefil, Puerto Rico Department of Natural Resources
E. E. Addor, Waterways Experiment Station
James Manning, Louisiana Wildlife and Fisheries Commission
Peter Frank, USDA Agricultural Research Service
A. Leon Bates, Tennessee Valley Authority
P. C. Quimby, Jr., USDA Agricultural Research Service

11:45 a.m. Panel Summary, T. E. Freeman

12:00 Noon Lunch

1:30 p.m. Panel - The White Amur for Management of Submersed Aquatic Plants

Moderator: R. F. Theriot, Waterways Experiment Station

A. Lake Conway Project

Don Blancher, University of Florida
Roger Conley, University of Florida
Roy Land, Florida Game and Fresh Water Fish Commission
Larry Nall, Florida Department of Natural Resources
John Bateman, Orange County Pollution Control Department
Roy McDiarmid, University of South Florida
Tom Fontaine, University of Florida

B. General Considerations

Katherine Ewel, University of Florida
Janice Hughes, Louisiana Wildlife and Fisheries Commission
Scott Henderson, Arkansas Game and Fish Commission
Forest Ware, Florida Game and Fresh Water Fish Commission
Woody Miley, Florida Department of Natural Resources

3:00 p.m. Break

3:15 p.m. Panel Summary, R. F. Theriot

3:45 p.m. Panel - Mechanical Control Technology Development

Moderator: C. B. Bryant, Aquamarine Corporation

John Neill, Limnos, Ltd.
P. A. Smith, Waterways Experiment Station
Moody Culpepper, Waterways Experiment Station

Jim McGehee, Jacksonville District
Richard Koegel, University of Wisconsin
Charles Hummer, Panama Canal Company
Larry Bagnall, University of Florida
Thomas Kelpin, Carver Aquatics
Harry McGill, General Development Corporation
Howard Grisham, Astor, Florida

4:30 p.m.	Panel Summary, C. B. Bryant
4:45 p.m.	Meeting Synopsis - W. G. Shockley, Waterways Experiment Station
5:00 p.m.	Final Adjournment

12th ANNUAL MEETING

U. S. ARMY CORPS OF ENGINEERS

AQUATIC PLANT CONTROL RESEARCH PROGRAM

INTRODUCTION

As a part of the Corps of Engineers Aquatic Plant Control Research Program (APCRP), it is required that a research planning meeting be held each year to provide for professional presentation of current research projects, review of current operations activities, and review of new research proposals. The contents of this report present the presentations and discussions conducted at the 12th Annual Meeting held in New Orleans, Louisiana, during 3-6 October 1977.

Historically, these annual meetings consisted of a series of presentations of technical papers on research conducted during the previous year. While these presentations proved very informative, there was a lack of desirable open exchange, on a discussion level, between researchers and operations personnel. Such an exchange was deemed necessary in order to define mission problems in such a context that future research objectives could be clearly identified and related to the operational elements' needs.

In an attempt to provide a forum for such an exchange, the format of the 12th annual meeting was designed as a series of panel discussions. These panels were staffed with both operations and research personnel who discussed both operational and research aspects of aquatic plant control and fielded questions from the audience. The entire proceedings were recorded and the resulting tapes were transcribed into 690 pages of typewritten text. The text was then edited and condensed into this document which comprises the proceedings of the meeting.

The first priority of the APCRP is technology transfer. The APCRP addresses four specific sectors in effecting this transfer. Each research effort conducted under the APCRP is required to report their technical findings to WES each year in the form of quarterly progress reports, an in progress review, and a final technical report. Each

technical report is given wide distribution of over 400 copies as a means of transferring technology to the technical community. Timely results are periodically published and distributed through an APCRP Information Exchange Bulletin as a means of technology transfer to the general community, with a distribution of over 1000 copies. In addition, general public oriented brochures, movies, and speaking engagements are available. Technology transfer to the field operations elements are effected through the conduct of demonstration projects in various District office problem areas. Field manuals are being assembled to serve as the final product of technology transfer to this sector.

The printed proceedings of the annual meetings are intended to provide Corps management with an annual summary and guide to insure that the research is continually being focused on current operational needs on a nationwide scale.

Appendix A is an executive summary submitted to the Office, Chief of Engineers, at the conclusion of the 12th Annual Aquatic Plant Control Research Planning Meeting.

PROCEEDINGS

RESEARCH PLANNING CONFERENCE ON THE AQUATIC PLANT CONTROL RESEARCH PROGRAM

WELCOME

by

COL E. J. Rush

Thank you very much. I wish to welcome you to New Orleans on behalf of the Corps of Engineers.

I think that it's quite appropriate that you hold your meeting here because the original Corps waterhyacinth control program began in the New Orleans District back at the turn of the century. Also, the Louisiana Congressional Delegation was very instrumental in getting legislation enacted on the expanded aquatic plant control program in 1958, and of course that program continues in effect today.

Also I think it's appropriate to have your meeting here because in Louisiana we do have some eight million acres of freshwater lakes, canals, rivers, waterways, and wetlands that are subject to aquatic weed infestation.

And, of course, last spring we estimated that about 500,000 acres of the water bodies in the State of Louisiana were infested by waterhyacinth and other aquatic weeds. And, unfortunately, with the dry weather that we've had this year, the low water conditions have allowed the seeds from the aquatic weeds to be exposed. We expect that there will be a significant increase in the waterhyacinth population.

As we all know, the aquatic plants interfere with such things as navigation and recreation, drainage, irrigation, and other water uses, all of which cause losses in this particular area to oil and gas exploration and production, commercial and sport fishing, fur trapping, waterfowl, boating, and any other water-related recreational activity.

To reduce these problems, the Corps has its Aquatic Plant Control Program. Here in the State of Louisiana we have a companion program

with the State. Together we're spending about $2 million a year to try to control these infestations, and we use about a hundred full-time people for field control and research.

In this District we're vitally interested in research because we believe that it will ultimately lead to a solution for the control of aquatic weeds. To this end, we've been cooperating with the Waterways Experiment Station in studying methods of natural control using insects and plant pathogens against waterhyacinth, and in trying to develop vehicles that will allow us to get into some of the inaccessible areas. We are also hoping to use remote sensing techniques to identify and qualify our present aquatic weed problems and, hopefully, to predict where outbreaks are likely to occur so that we can implement effective field control.

So, the purpose of your meeting, as I see it, is to exchange information on what techniques are currently being used in the field for aquatic weed control, to assess the status of our present control program, and to define subjects that are in need of additional research. We certainly hope that your efforts this week will help make control operations more effective and economical.

I wish you a very productive meeting.

THE CORPS OF ENGINEERS' AQUATIC PLANT
CONTROL PROGRAM

by

H. R. Hamilton

As you know, we are organized under the Chief's Office and have ten divisions under that, and about 38 districts under those ten divisions, and some 438 reservoirs or lakes under those districts, in addition to the 22,000 miles of navigable waterways. So, it's a big--I almost said problem. We don't have any problems, but we have a lot of opportunities. But it's a big management effort. And I've been very fortunate in being able to participate in that over the last three months.

As a result of that, I don't know a whole lot about what's going on at the Chief's Office in aquatic plant control.

Lt. Claudia Akroyd probably knows a whole lot more that I do with regard to what's going on in aquatic plants at that particular level.

From the division level, however, I have really found out some things that I didn't know. For example, we're doing mechanical harvesting at Orange Lake in Florida, and Joe Joyce is having this material dumped in the water so that we're creating breeding and wallowing areas for alligators, which are an endangered species.

As you know, we started this intensive management effort on aquatic plant control two years ago last spring, and we have done a lot of things in that time. It's really surprising. It seems as if you take one step forward and slide back about three. But when you stand back and take a look at it and really analyze where you were a couple of years ago, and where you are now in relation to where you want to be, we've come quite a way and we've made some successes.

First, we started with the philosophy that we are going to manage the program; the program is not going to manage us. I think that we have had success with that attitude. We put it on the basis of assigning priorities to our work in establishing goals and objectives and target dates, what we call good, sound management, and I think it's paying off.

We decided to drop the losers, like laser beams and some other things--I call it research for the sake of research.

But we did drop the losers, and we picked up some things that looked like potential winners. These items we thought we could translate into tools for our operations people to use in the effective management and control of aquatic plants.

An example is the white amur, the controversial fish. We stocked that amur last month in Lake Conway and we've got over a year's baseline data. We're going to continue to monitor that and we're going to try our best to really find out who's right. Is that an effective tool or not? Does it have an adverse or a beneficial impact upon the aquatic ecosystem? We haven't found anybody that really knows in relation to American waters, and we're trying to find out. I hope it's successful.

We're doing some new things in mechanical harvesters. Our biological control is really beginning to blossom with the use of insects and pathogens on a large-scale test in Louisiana.

We've even been to Panama. Lewis (Decell) and his people have been down to Panama with Colonel Custer, and I think we're learning a few things there.

I'm talking in very general terms because everybody's going to be talking in more detail as we go along.

I did want to point out that we have put the program on a good management basis and are continuing to do that. Claudia Akroyd is going to talk to the Corps people later this morning about the new budgetary procedures with which we are trying to increase the funding. I think we've succeeded in that to some degree, because certain people are concerned that we give them too much money. But we're going to keep getting that money, and we'll keep putting it to an effective use. We're not going to waste the money, I guarantee you that. We're going to have a successful program and I think we're off and running. Thank you.

KEYNOTE ADDRESS

by

D. V. Lee

I would like to say that it is an honor to be the President of the Aquatic Plant Management Society for this particular year. The society is a growing society, much in the respects of this particular group of people. I can remember the first meeting that I attended, here in New Orleans, and there were only about 30 people present. The following year it was in Texas and there were about 20 or 30 people there. So, by looking around you can see that this particular facet of aquatic weed management is also growing.

The Aquatic Plant Management Society has two chapters, the Florida Aquatic Plant Management Society and a chapter in Mexico. So, I would like to issue you an invitation. If you are not currently a member of the Aquatic Plant Management Society, I think that by affiliating yourself with that particular group you will be able to keep up with the many developments that are taking place in aquatic plant management control.

I would also, as a resident of the State of Louisiana, like to extend a welcome to you.

So with that--the insufficient quantity of water in many parts of the United States in recent years has clearly demonstrated water is becoming a most precious and limited resource. Agricultural, industrial, and urban development; navigation; and recreation have been limited in many areas because of deficiencies in quantity and quality of available water.

Your attendance at this conference could be related directly to the continuing increase in public concern over aquatic weeds that are wasting water and interfering with the many economic uses of this extremely valuable resource.

Each of you has observed the fact that some form of vegetation occurs in and/or adjacent to all streams and bodies of water. We are all

aware that plants are as essential to the aquatic environment as they are to the terrestrial environment.

In water they provide the basis of the food chain for other types of aquatic life, and they form the habitat for much of the aquatic fauna. Vital as they are, excessively large populations or masses of aquatic plants become highly detrimental to other aquatic organisms and reduce the usefulness of water for many other purposes. The importance of aquatic weed management and control is, therefore, closely related to the importance and value of the water in which weeds occur.

There are over 150 species of aquatic plants known to interfere with water resource use and management. Aquatic weeds are usually grouped in the following types: algae, floating, submerged, emergent, and marginal. These types of weeds cause losses or create nuisances in aquatic areas in many ways.

Aquatic weeds clog drainage in irrigation channels and ditches; obstruct navigational channels; limit fishing, hunting, boating, and swimming; provide breeding places for insects and other pests; contribute to the collection of sediments; cause damage to bridges and other structures; cause breakage of canal banks; and affect the health and comfort of people and livestock by causing undesirable odors or taste in potable water and by interfering with public sewage disposal and stream sanitation.

Many emergent aquatic weeds transpire large quantities of water, causing serious losses in areas of water shortage.

Where do aquatic weed problems occur? Statistics from an agriculture census, which have been used by Timmons, Cones, and others, show that there are approximately 66,000 square miles of inland aquatic situations where weed infestation could occur. This approximate total includes over two million acres of ponds and lakes less than four acres in size; twenty million acres of large lakes; 200,000 miles of irrigation channels; and 250,000 miles of drainage channels.

In a recent report from USDA, ARS, it was estimated that nearly all of the small ponds were infested with nuisance levels of aquatic weeds. Those estimates indicate that 40 percent of the area of large

lakes, 63 percent of the area of irrigation canals, and 75 percent of the area of canals and ditches are infested with nuisance levels of aquatic weeds.

Current and reliable statistics on economic losses due to aquatic weeds are almost nonexistent. According to the U. S. Bureau of Reclamation, the cost of weed control on irrigation projects with which that agency has contractual relations was nearly $10 million in 1975. This figure represents 30 percent of the total operation and maintenance budget for these projects, which involve a total of 56,000 miles of waterways and serve 9.4 million acres of irrigated land. Cost for weed control on these projects averaged $178 per mile or $1.60 per acre of irrigated land.

Information compiled by USDA, ARS, indicates that $20 million was spent in Florida in 1976 on the control of waterhyacinth and hydrilla. The cost of control programs conducted by the Louisiana Department of Wildlife and Fisheries and the U. S. Corps of Engineers in Louisiana amounted to $2.9 million; however, we've updated that figure. I think Wildlife and Fisheries spent $1.6 million last year and the Corps, approximately $1.5, so that's $3.1 million spent in Louisiana.

Texas spent $300,000 on its control program conducted by the Parks and Wildlife Department. Control costs for the other southern states listed were not available.

Other estimates of the losses in the United States, due to aquatic weeds since 1960, ranged up to $110 million annually. These estimates do not include losses due to crop failure, interference with nagivation on streams, degradation of recreational facilities, deterioration of wildlife and fish habitat, drastic depression of property values, or injury and disease to man and animals from insects harbored by these large masses of weed infestation.

In 1965 the direct losses to agriculture caused by aquatic weeds amounted to $52 million. The net productive value of lost water alone was estimated at $91 million that year.

Aquatic weeds are most noticed by the public in lakes over 40 acres in size. It is in these water bodies that the greatest demands

will arise for improvement in the environment through management of aquatic weeds. While these inland waters serve many purposes, the most important industry supported by this resource is recreation. The extent to which aquatic weeds influence or affect recreation has never been determined. In numerous instances, major recreational resources have been completely eliminated by unrestricted growth and spreading of such weeds as hydrilla, waterhyacinth, and alligator weed.

For the year 1970 the Bureau of Sport Fisheries and Wildlife provides some information on the beneficiaries of wildlife programs in the magnitude of the recreation industry. During that year 14,386,000 hunters devoted 86 million recreation days to hunting at a cost of over $2 billion. Waterfowl hunters alone spent more that 25 million hunter days at this sport at an average cost of $84 per hunter. In addition, more than 38 million persons devoted a total of 786 million recreation days as bird watchers, wildlife photographers, nature walkers, etc. These activities are critically dependent on aquatic areas and should be a vital concern in aquatic weed control research programs.

Fishing, as a recreational pursuit, exceeds all other outdoor sports depending upon water. Excessive and unmanaged aquatic vegetation is particularly destructive to fisheries habitats and the quality and economic value of fishing as a sport.

During the year 1970 the Bureau of Fisheries and Wildlife reported 28 million fishermen spent more than 706 million recreation days at this sport at a cost of $5 million, or about $150 per fisherman.

By the year 2000 it is estimated that the total inland fisheries waters will increase to about 92 million acres, primarily in the form of warm-water reservoirs where aquatic weed problems are the most severe. At the same time it is estimated that there will be 63 million fishermen. Much of the additional water required to satisfy the needs of fishermen must come from the existing water sources by rehabilitating large areas of water now unfit for fishing because of eutrophication and the accompanying infestation of aquatic weeds.

The Bureau of Sport Fisheries and Wildlife lists the value of a fishing effort at $6.30. That's one fellow going out one time to catch

a fish or to attempt to catch a fish. Their survey in 1970 estimated 22 fishing efforts annually per acre of fishable water. In Louisiana these two figures are used to compute aquatic weed control program benefits as a justification of budget requests.

It is estimated that the waterhyacinth control program has a direct input in maintaining 3,059,366 acres of water in Louisiana. If we multiply this acre figure by the value of a fishing effort, which is $6.30, times fishing efforts per acre, we have an immediate annual benefit of $424,028,127. Unrealistic? Considering the growth characteristics of plants like waterhyacinth, Eurasian watermilfoil, and hydrilla, what do you think?

We have discussed briefly some of the many problems caused by aquatic weeds, along with the available economic assessments and relations. However, there is one statistic we seldom consider as a completely independent entity when we discuss aquatic weed control.

This statistic is the actual number of individuals who are benefactors of aquatic weed control programs. How many people receive direct benefits? How many people receive indirect benefits? Computing figures to compose this statistic is very much like computing the related economic values. What limits do you place on indirect benefits? How much overlap do you have within benefactor groups? An example of this is how many fishermen are also trappers or waterfowl hunters or landowners? And, in contrast, how many trappers and waterfowl hunters and landowners are not fishermen? It's a complex game.

For the past four years Louisiana has been going through the process of reorganizing the state government. As with any experiment, the results must be evaluated. Last week we received the latest in a long line of questionnaires apparently designed to evaluate the reorganization and to justify the existence of the top level personnel which were hired after reorganization.

One of the directives in the nineteen pages of the form was to identify the current population receiving benefits, direct and indirect, of the program provided. The reply given to this particular directive was as follows: "The client population which received direct benefits

from aquatic weed control programs in Louisiana includes fishermen, sport and commercial; trappers; waterfowl hunters; individual boat owners; shoreline property owners; municipalities which depend on water and on lakes and reservoirs for a domestic water supply; individuals whose livelihood depends upon services to listed benefactors (that is, recreational equipment manufacturers, distributors, resort owners, etc.) and water-oriented recreation participants (that is, swimmers, conoeists, campers, picnickers, skiers, etc.)." This direct population is estimated at 2,311,740.

In arriving at that figure we estimated that in Louisiana the number of licensed fishermen is 450,000 each year. In a recent survey conducted by our department, it was determined that for every fisherman that has a license, there are two people who fish that do not have a license. So, using that survey, we come up with a figure of 1,400,000 people that are fishing in Louisiana.

We had 250,000 individual boat owners. We realize there is an overlap in boat owners and fisherman, and we would say that about 70 percent of the people who own boats fish, so we come up with only 75,000 people who weren't included in the fishery group.

We took each of these items and broke them down using these statistics, which again is a complex guessing game.

Client populations which received indirect benefits from aquatic weed control programs include: nearly all agricultural interests; those persons dependent on aquatic weed control for maintaining channels for irrigation and drainage; residents of low-lying pastures needing flood control drainage; oil companies which operate in inland aquatic situations; commercial navigation and water transport interests; commercial industrial plants and generating facilities which depend on water from reservoirs and streams for cooling and fire protection; and the general public, whose health is dependent on the reduction of areas which harbor insect pests and vectors of human diseases.

This client population is conservatively estimated at 250,000 additional individuals. We feel it could be higher.

In Louisiana we have a population of approximately 3.5 million

people. Of that population it is estimated that 2,561,740 individuals receive benefits from the aquatic weed control program conducted by the state. We conclude that this aquatic weed control program is extremely important to the people of Louisiana. We also feel a similar parallel could be drawn for any aquatic weed control program in the United States.

We have stated that water is a valuable natural resource. Aquatic plants grow in most of the water we are discussing, and these plants are an essential part of the aquatic ecosystem. We have also stated that too many of these plants soon become weeds which must be managed and controlled to provide the necessary benefits from our water resource. We, as individuals, are receiving the benefits outlined; therefore, the methods we are using as aquatic weed control professionals must be at least partially effective.

A quick reveiw of the history of aquatic weed control shows that the construction of two crusher boats built by the U. S. Corps of Engineers in 1900 was the first major attempt at destroying large infestations of aquatic weeds, in this instance the waterhyacinth. These boats were abandoned in 1902 because of their inability to keep up with the rapid growth of the hyacinth plant.

From 1902 to 1937 sodium arsenite was used rather extensively in several parts of the country for aquatic weed control, particularly waterhyacinth control in Louisiana. We found that copper sulfate, still our most widely used algaecide, was used as early as 1904. Sodium arsenite was used as early as 1926 to control submerged weeds in lakes and ponds, and that method continued for a number of years.

In 1937 mechanical weed control techniques again emerged as the primary effort against waterhyacinth. In the early 1940's chlorinated benzenes were used to some extent in eastern ponds and lakes and in western irrigation canals.

In the mid-1940's the development of 2,4-D shifted the major efforts to control waterhyacinth back to chemical application. The interest and emphasis toward the development of aquatic weed control technique and methodology as a separate weed control discipline did not begin until 1957.

During the past twenty years widespread interest in the control of aquatic weeds has led to the development of a range of control techniques more commonly referred to as an integrated approach. These control techniques include biological, preventative, mechanical, and chemical methods.

Biological control agents such as the alligatorweed flea beetle, *Vogtia malloi*; two species of weevils and the moth which attacks waterhyacinth; the white amur; and several plant pathogens are becoming increasingly important as potential biological control agents.

The success of these agents should reduce the total reliance on herbicides for the control of some species of aquatic weeds. You will be exposed to more information about biological control agents later.

Preventative control usually involves the careful planning in the construction or renovation of ponds, reservoirs, irrigational canals, and drainage ditches. Preventative control techniques can be used to excellent advantage in preventing aquatic weed problems or facilitating other control techniques.

Mechanical techniques employ physical forces to remove aquatic weeds or alter environments so that the plants cannot become established or cannot survive if already present.

Most aquatic weed control manuals usually classify the practice of water manipulation as a mechanical control technique. This practice can be used successfully in systems where it is possible to raise or lower water levels, or where water can be removed completely from the stream or impoundment.

Although chemical control of aquatic weeds has replaced mechanical methods in many situations, improved mechanical techniques are still being used extensively and have certain advantages. Some of these advantages include no direct hazard to fish, wildlife, livestock, or humans. However, such methods are slow, expensive, and often laborious. Most of the time they provide only partial or temporary control, and they often increase the spread of submersed weeds.

The development of technology which will allow for economically feasible utilization of aquatic weeds could offset somewhat the high

cost of mechanical removal, thereby making it more profitable to remove the weeds mechanically.

If research should be successful in developing practical uses for aquatic weeds, it would open the door for an almost inexhaustible supply of an available resource. The field trip scheduled to NASA will provide you with some current insight regarding the utilization of some aquatic plants.

Today most programs for the management and control of aquatic weeds are accomplished primarily with herbicides. This method has the advantage of being faster, easier, usually longer lasting, and generally less expensive than mechanical control. Most of the herbicides now used for the control of aquatic weeds have low toxicity to humans and other warm-blooded animals, are harmless to fish in concentrations necessary for the control of weeds, and will not injure crops if you use them in accordance with the label.

Nevertheless, the use of herbicides is greatly restricted. A great many of the restrictions on the use of herbicides are due to the lack of data concerning the effects on the aquatic ecosystem.

Since 1968 the number of herbicides listed for domestic aquatic uses has been reduced from 35 to less than 10. Most of those remaining have been retained largely because of the developmental work carried on or financed by federal agencies. Later in the program we will hear more about chemical control and the associated regulations.

We have seen many advancements in aquatic weed control within the past few years. However, it is readily evident that much new technology is still required to provide meaningful control methods for many of the submerged weed species, particularly hydrilla. It has been reported that the technological advances in the control and management of aquatic weeds have not been sufficiently adequate during recent years to solve the existing problem.

The increased concern about the effects of control operations, particularly herbicide application, on the aquatic environment has diverted most of the available manpower to environmental safety studies designed to retain control methods then available or currently available.

Also, we have been involved in a long and painstaking period of development of new criteria which will regulate the development of new chemical products. These two things have been the major reasons for the seemingly limited development of new technology for aquatic weed control.

It should be pointed out that chemicals for aquatic weed control are generally termed a minor market by the chemical industry. Some of our more responsive chemical industry people are aware that aquatic plant management and water conservation have a potential to reduce the demand for large quantities of agricultural chemicals. Those fellows certainly would like to maintain their agricultural chemical sales.

It is imperative that extensive fundamental research be continued. Without the knowledge derived from this research, it will be impossible to develop the control technology needed to cope with the problems caused by aquatic weeds. It has been reported that the Florida Department of Natural Resources anticipates the cost of aquatic weed control to increase to $100 million in ten years unless there are substantial improvements in control technology.

Nationwide, the potential monetary benefits from this research probably exceed those of any other area of weed control. The possible objectives of this research should continue to be to retard or prevent the spreading of aquatic weeds and to reduce current weed infestation to levels that are commensurate with the principal use of the water.

If we are successful in this research, some of the things we could expect include safer, more economical and longer lasting control; reduced losses to agriculture; more selective types of permanent weed control; larger areas of waters that provide high-quality recreational opportunities; extension of benefits of control to previously inaccessible areas; increased understanding of the behavior and fate of herbicides in water, which could lead to broader latitude in herbicide usage; and improved means of assessing beneficial and detrimental effects of control.

I think you can see that aquatic weed control research and the development and implementation of control programs are an extremely

important and necessary service that we, as professional aquatic weed managers, are providing for the people of this country and for the world.

THE MANAGEMENT PLAN CONCEPT AND ITS APPLICATION FOR THE FUTURE OF CORPS OF ENGINEERS AQUATIC PLANT CONTROL

by

J. L. Decell

I ran across a quote the other day that seemed appropriate, especially in light of some of Roger Hamilton's comments about reorganizing this program. It goes like this.

"We trained hard, but it seemed that every time we were beginning to form up into teams we would be reorganized." I was to learn later in life that we tend to meet any new situation by reorganizing; and a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency, and demoralization.

I'm sure all of you have been subject to some reorganization at times. I have to admit that a couple of years ago there was some confusion, and there still is a little confusion. I hope there's less inefficiency in the way we go about our tasks, and there certainly hasn't been any demoralization. If there has, it's just been at times we sit back, like Roger said, and we look at things and we say, "We've still got a lot of work ahead of us," even though we've made some strides along these lines in our program.

The man this quote is attributed to said this in 210 B.C. He was a captain in Caesar's legions. Likewise, there are legions of people, as Don Lee commented in his keynote address, who are involved in aquatic plant control. A couple of years ago, when we had to wrestle with deciding the one thing we could put our finger on in order to find out what our job is, or more specifically, how we should go about transferring the technology from research to the user, the same word kept coming up. There's a society that uses it, and Don Lee said it many times. Hamilton said it many times in his talk this morning, and it's "management."

As we thought about this we tried to decide how one goes about the job of managing an unmanageable aquatic plant. And, more basically, we

wondered: How can we provide a framework from which someone can consider the environmental constraints; consider the possible control measures; consider what is coming out of the research programs at both the state and federal levels; and, in a very complex process, put these together and make the trade-offs and come up with something that's manageable, that actually does the job of controlling aquatic plants?

So, what I'm going to talk about today is a concept that we generated at WES that really evolved, if you will, from a lot of ideas over a two-year period. And we haven't identified anything new. What we've done is formalize a process that has been going on, and is still going on, and will continue to go on as we go about our job of aquatic plant control and research.

You ask yourself the question: What's the value? Well, the value is it's a road map. Road maps not only get you where you want to go, but they allow you to see branches in the road, alternatives, so that you can make decisions ahead of time. You can also look back and see the route you took to get there, and you can analyze that.

We've published a report that covers this in some detail. A flow chart lays out the step-by-step process, and we hope it will provide a guideline for people to develop aquatic plant management plans for their problem areas.

This morning, I'd like to touch on some highlights of this plan. If you'd like a copy of this report, I'm sure we've got several at the Waterways Experiment Station.

The concept for the development of the aquatic plant management plan was formulated for the purpose of providing a guideline for the systematic consideration of all existing control measures that may be brought to bear on any given aquatic plant problem. Such consideration should result in a well-conceived management plan that provides guidance for complete and continual assessment of the problem, evaluation of control alternatives and their effects, and step-by-step implementation of control procedures.

Adhering to such a plan can reduce the cost of materials and labor. It can decrease the time required to achieve control. It can

increase that degree of control and can, hopefully, prevent duplication of effort.

The concept is intended as a basis for developing management plans which will provide the user with a step-by-step guide for implementing long-term aquatic plant control, while at the same time giving proper consideration to the potential long-term effects on the aquatic environment.

The concept is built around and identifies five distinct phases that are necessary, as we see it, for development of a plan and successful implementation of management of problem aquatic plants. These phases are, first, the problem identification and system description phase; second, the data analysis and collection and analysis phase; third, a process that results in a selection of optimum control techniques; fourth, a development of an operational plan; and the fifth phase, obviously, the operational plan implementation and follow-up monitoring of that plan.

Problem identification and system description, on which there will be a panel later today, simply involves accurately identifying both the type and scope of the plant problem. In addition, in this process it is necessary to identify the physical characteristics of the problem environment. As in most cases, the nature of these usually has a large influence on the selection of the control alternatives. In addition, one must decide at this time what level of management effort relates to the problem.

We've identified in this process three different levels of management that are problem related: management for the purpose of control, management for the purpose of maintenance, and as Don (Lee) mentioned, management for the purpose of prevention of the problem.

We characterized the population level of the target species in relation to time. There is a "zero population level" of the plant, and a "zero problem level." What this implies is that there is a level of aquatic plants that we will have to learn to live with. This level, however, is not a problem to the things that have been mentioned this morning, such as recreation, navigation, water uses, and water quality.

I don't think this is an unrealistic view of the population level. We're not to eradicate the aquatic plants. As Don Lee mentioned, they do provide habitat for certain organisms in the aquatic ecosystem that are part of the food chain.

Above the "zero problem level" is the "maximum acceptable problem level." This is the level defined as the maximum problem you can live with. Having identified these levels, we have said that anything above the maximum acceptable problem is unacceptable, and anything below that is acceptable, although it's desirable to prevent the problem or bring the problem to the level that's desirable. These levels are related to the control, the maintenance, and the prevention, in our hierarchy of the types of management.

We've identified in the process of this management scheme, this development scheme, elements necessary for successful management of aquatic plants. These are surveying, reporting, treatment, training, and public awareness. As I said, these are treated in more detail in the report, but I'd like to hit the highlights.

All of you are engaged in, or should be engaged in, all of these elements. I'm sure that operational people relate to the reporting, surveying, and treatment. Public awareness is a full-time effort in the management of aquatic plants and a very critical one. Training of the personnel who engage in the actual plant control is very critical.

Phase Two of the development of any management plan involves the collection of data and analysis. These necessary data will encompass not only the problem, scope, and character, but also the data related to user interest, environmental constraints, and the expected performance of available control methods. The predictability of these control methods and the operational data will be of value at such time as the plan is implemented.

Phase Three of the development plan involves and identifies the process that leads to the selection of control techniques. During this phase, data on the problem, the potential control methods, the user demands, and the environmental considerations converge in a trade-off process. The result of this trade-off is the selection of a control

method, or methods, in the case of integrated control.

The assumption is that the method chosen provides maximum possible control without exceeding the constraints of the system, such as environmental and user constraints, recreation demands on the water bodies, etc.

Phase Four involves the operational plan development. It is in this phase that the actual battle plan is formulated. Prior to this, all evaluations and trade-off considerations have been completed, and a control method (or methods) has been selected. The detailed operational plan must be developed to insure that the distribution of selected control agents is accomplished on a rational basis and in a proper sequence.

The last phase of the management concept deals with the operational plan implementation and monitoring. It is at this point in the overall management that the medicine is administered, so to speak. We've written a prescription following a thorough diagnosis and have defined the manner in which the treatment is to be administered. Following this procedure the treatment is implemented and the after effects are systematically monitored.

This follow-up on the operational plan will inherently infer a prediction of the degree of success expected. This provides the yardstick. The systematic monitoring and reporting of the implemented plan provides the data and information necessary to judge whether or not the degree expected is being achieved. There, again, the reporting process is continual even after operational plan implementation.

Whether or not the implemented methods solve the problem totally or partially is not the entire issue. Equally important is that each time a problem is attacked, following a plan, we will gain some knowledge of why it did or did not succeed as expected. Without both the operational plan and some degree of follow-up monitoring, we will have to continue to rely on anecdotal information as to the cause and effect of our action. This could hardly be construed as effective management.

Public awareness is an integral part of any aquatic plant management plan, as I'm sure people at the State level will tell you. I know

firsthand that in the States of Washington, Louisiana, and Florida, meeting with the public, erecting signs, and educating the public as to the nature of aquatic plants and their potential problem have been implemented and are fairly effective.

During this past year we've used this concept to formulate an operational plan which was subsequently implemented by the U. S. Army Engineer District of Tulsa, Oklahoma. Follow-up monitoring is presently being conducted, and you will get some reports on that as the meeting progresses.

This year, two more problem areas will, or are scheduled to, implement plans as developed under this management plan system. They are the South Carolina Public Service Authority and the Lake Seminole, Georgia, Project of the U. S. Army Engineer District in Mobile, Alabama. At this time, these efforts are a test of both the concept and the operational methods implemented. We are confident that this approach will be both valuable and useful in the future, and with your help will most certainly be improved.

During the coming year, in several projects that have been identified as having potential aquatic plant problems, we'll continue to coordinate with the districts and with the state agencies. We'll apply the philosophy of this framework for development of long-term management plans for aquatic plants, and we openly solicit any suggestions from the people at the state and federal levels involved in aquatic plant management.

I'll conclude by trying to give you a summary picture of why we chose to differentiate three levels of management in aquatic plant control. Some of you may think it's a subtle distinction, and it may be. Some may argue that maintenance is control and control is maintenance.

However, if we look at the options we have for application to the problem and consider the relative level of effort required in each one of the phases of surveying and treatment, and the cost thereof, we will find that in the area of prevention, the level of effort in surveying and monitoring is very high. The cost of it is not proportionately as

great as the high level of effort required for application of the control method. Consequently, the cost is low in the overall effort of prevention of aquatic plants. In the maintenance, the cost is a little higher. The level of effort in both treatment and surveying is about the same.

When we find out about a situation after it's already a problem, there's neither time nor necessity to survey the problem. We know where it is and we know what is is; we don't have a lot of options left open to us.

The only other facet that I can mention, that's significant of this distinction, is the fact that in prevention you have many methods of control and management techniques that are not available to you when you've already got 9000 acres of an aquatic plant problem.

So far we feel this technique is working, although we haven't had a lot of feedback. We'll make a concerted effort during application of this process to push for prevention--that is, management for the prevention of aquatic plants and maintenance of those existing problems before they become major problems.

Thank you.

ADMINISTRATION OF CORPS AQUATIC PLANT CONTROL
PROGRAM BUDGET

by

1LT C. N. Akroyd

I realize many people are upset about the level of funding that they have received in the past and for FY-78, and I'm going to try to explain to you why this has occurred and will probably continue to occur for awhile.

The purpose of this briefing is not so much to instruct you on how to prepare a budget submittal, but to explain what happens to your submittals after they reach the OCE level and the interworkings of the budget process.

I'm only going to deal with the portion of the project for aquatic plant control that constructs some general portions of the program, because most of the people are involved only in that. I want everybody to feel free to ask questions at any time.

Before I get into the budget process, I would like to briefly run through the history of the program for those of you who are new either this year, or in the recent past.

Basically the Corps has two programs that deal with aquatic plant control. The first one is cited as the River and Harbor Act of 1899. This is an Operations and Maintenance (O&M) Project and it's commonly referred to as the RAG Program, Removal of Aquatic Growths. The second one is the River and Harbor Act of 1965, Public Law 89:298, more specifically, Section 302. This is the construction general portion of the program and encompasses a nationwide program.

The O&M authority basically allows for the destruction and removal of waterhyacinth from navigable waters of five states, Florida, Alabama, Mississippi, Louisiana, and Texas, so far as they constitute an obstruction of commerce, using any means available, except in Florida where chemicals injurious to cattle are prohibited. It allows for the use of boats equipped with machinery suitable for such destruction or removal, and the use of booms to close flows and backwaters to prevent plants

from drifting from one stream to another.

The original authority, as cited in 1899 allowed only for the removal of waterhyacinth that cause obstruction in navigation by the construction and operation of suitable vessels and for the use of log booms as adjuncts to the operation of these vessels, only in the States of Florida and Louisiana. In 1902 it allowed for the use of any mechanical, chemical, or other means in Florida and Louisiana. In 1905, Texas was introduced and a stipulation on chemicals used in Florida was added. In 1907, it was basically the same. In 1912 Mississippi was added, and in 1916 Alabama was added. So actually, the authority as cited by the 1899 act actually comes about from the laws amended by 1916.

Most of you, practically everybody in this room, works under a construction general authority. The legislative history for this began in 1968 when it was a pilot program. In 1904 it was Public Law 85:500, which only allowed for control in North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. This provided for an expansion of the program that was then under way, the River and Harbor Act of 1899, with approximately an additional $1,350,000. This was divided up on a 70 percent Federal, 30 percent state basis. It did not really go into who allocated the funds for research and planning.

In other words, in 1962 when Section 104 was amended, it was stated that: "Section 104 is hereby modified to provide that research costs and planning costs of the construction shall be borne fully by the United States and shall not be included in the cost to be shared by local interest."

In 1965 this was all incorporated into Public Law 89:298, Section 302, which is what we have today.

The funding history that I will discuss starts in 1972. We've been on a slow but steady increase, to the highest to date in FY-78, $2,370,000. Mr. Hamilton mentioned earlier that some people are getting so much money that they're having trouble using it. The primary reason for this is not so much the allocation from OCE, but the Congressional add-ons. That is how we got the $70,000 increase this year, and that was earmarked for Louisiana.

The average is slowly rising and now stands at $1,890,000. The general program priorities have caused a lot of confusion in the engineering circular we put out on the budget this year. These are designed to be overall program priorities, not necessarily what the Districts should take as gospel. We do wish to see technology transfer at the top of the priority list because this will eventually benefit all districts and divisions. So, it stands that research is No. 2 and cost-sharing control operations are subdivided into those operations primarily for navigation and those for other purposes. This is consistent with the Corps' responsibility for the navigable waterways.

Now, I'd like to get to the timetable. This does get rather complicated.

In April, representatives are supposed to go into the field. This year we intend on sticking with that, although unfortunately, as most of you are aware, we had sort of a short fuse this year. This was primarily due to the institution of zero-based budgeting. It was not clear how this was going to be instituted this year, since we're running dual systems--the old system and a form of zero-based budgeting. As far as next year goes, your guess is as good as mine. We won't know until we start getting feedback from the Office of Management and Budget, which isn't due for a while yet.

The Corps, basically, sets the general target level, which is decided between the Secretary of the Army and the Office of Management and Budget. Of that, we get a little piece.

Recreation convinces the Construction Operations Division what we feel our target level should be, and they then convince our Program people. It's based on other programs and their needs.

Basically, the target level is what we have to work with. However, once this is set, it is not the final word. We do still have a chance to argue for an increase of funding, and believe me, we do. But in order to try and get that increase, we need very good justification sheets, because without those we have nothing to back it up. Most of the time these are spur of the moment conversations with Programs people, and we have to get a word in whenever we can. Therefore, we don't

always have time to come back to you to get additional information.

By June 30th, we want to have the justification sheets in from the field. This is to give us plenty of time to look at them, work with them, and develop an overall justification sheet for the program.

This year, as a lot of you are aware, we instituted a new system in the engineering circular. We had divisions rank the districts on a priority basis for the individual operations and planning effort out in the field. This was to eliminate guess work on our part. We sit in Washington and don't see what happens from day-to-day out in the field as you do. Therefore, we need to know exactly where your priorities lie.

When you are juggling district against district, some arbitrariness does get into the picture, even though it's an educated guess. That's why we like to have the divisions ranked, so we don't have to juggle district against district, but merely division against division.

In July we prepare a budget level and justification. This is where timeliness in submitting your justification sheet really plays an important part. If one division, or say two divisions, are late getting their justification sheets in, it holds up the whole works because it may mean that we go back and rework the whole budget. It's important that we see everybody's submittals in relationship to everybody else's, so that we can allocate the very limited amount of funding that we have as best we can. Also, if any questions do come up, it gives us an opportunity to get back with you and ask for clarification.

In August our decision packages and justification sheets are due internally. You have received three handouts. The first one I'd like to point out has at the top of the page, "Appropriations, Title, Construction, General, FY-79." The next line is, No. 13, "Aquatic Plant Control Program." This is what Congress will see. This is also the old system under the planning-programming-budgeting system. This is not necessarily in its final form, but will give you an idea of the amount of space we have to justify this program. Usually we are limited to only two pages, but we were able to sneak in a little bit more this year.

The next item I'd like to call to your attention is what is

happening under the zero-based budgeting system. This is a decision unit overview, specifically, the one that states, "For Aquatic Plant Control Programs." This is what Recreation wrote up on the program and submitted to our Programs people. This goes along with what they call "decision packages," which are actually budget levels, such as the minimum of target and a maximum program which justifies each of these programs in relationship to what more can be accomplished over a minimum effort.

From these two pages, in our decision unit overview, we were "wrapped up," (which is a term you'll probably hear quite often this coming year), into special authorities and programs, which is the other handout that you received. This year we were wrapped up with streambank and shoreline erosion protection and with the employee compensation fund.

Underlined are the excerpts from our decision overview that were incorporated with the Special Authorities and Programs Division decision overview. This particular decision overview and the first sheet I pointed out, the justification sheet under the old system, are what Office of Management and Budget are acting on now, along with the decision packages.

Another new twist to the program is that the program has been divided. The research portion of the program is being submitted and covered under the R&D Office. The Recreation Branch still has the responsibility for budgeting this and preparing the justification, but it's being presented in terms of the overall Corps research program. This decision unit overview that you have before you covers only the control operations and planning portions of the program. By the time it gets to Congress the two will be merged.

In September, once it is cleared through the internal process, all the way to the Chief of Engineers, the budget goes to the Office of the Secretary of the Army for his approval. It is then transmitted to the Office of Management and Budget. Then someone from the Construction Operations Division goes over and testifies before OMB. Many times you only have about two minutes to justify an entire program.

Basically, this is the internal budget process, greatly simplified.

Those of you in the District who prepare your justification sheets send them to the Division, which compiles the Districts. These are then transmitted to the Recreation Resource Management Branch. Also, WES submits their plans to us. We coordinate with the Staff and the Management Office and the Research and Development people. The staff and the Management Office has the overall responsibility for manpower and research, for problem statements, and for the civil works portion of the Corps' research. The R&D people present the research portion of the program in their internal research presentation before OMB and again to Congress.

Next, we prepare our budget submittal and we get it cleared through the Construction Operations Division. Then it goes on to the Programs Division. The Staff and Management people and the Research and Development people also put their input into the programs to coordinate the entire civil works budget. At any time we can have things kicked back for reevaluation, or it comes down through channels that we need new information.

Next, it is presented to the Director of Civil Works who gives his approval or kicks it back, and on to the Chief, the Secretary of the Army, and finally to the Office of Management and Budget. This is where it is now, so I'm afraid I can't give you any news.

It is usually in November or December that we get the package back from OMB. Essentially, they make recommendations to the President and help the President formulate his budget. He then submits his budget to Congress in January.

In February the appropriations hearings start. This is where things can start flying. I'm sure that some of you recall that around last February I was frantically calling you for additional information.

At this time the President submits his budget to Congress. Both the Senate and the House act on this budget, and each portion of the Congress holds its own appropriations hearings. Various people go up and testify--the Chief of Engineers, the Director of Civil Works, the Division Engineers, the District Engineers, and also any persons

from the private sector who so desire.

OCE really has only two opportunities to get things in the Congressional Record, as far as the program is concerned. Things can be submitted to the Congressional Record and, possibly, even stated during the hearings by the Chief of Engineers and the Director of Civil Works. We also respond to questions that are sent back by the Senators and Congressmen during the course of a hearing. Many times we have only half a day to get these typed and back up to the Hill. This is why it is important that all the Division and District engineers be aware of the problem, and this is where you come into play. This is about the only other opportunity we have to get things brought before the appropriations committees.

The Congressional Budget Office is bipartisan. It provides statistics to both the Senate and the House and is at their disposal when they need other information. Both the Senate and the House act on their respective appropriations bills, and they meet in conference committees until they can come up with essentially the same type of appropriations bill. It is only at that time, when they come to some type of an agreement, which sometimes takes awhile, that Congress will pass an appropriations bill. This bill is then resubmitted to the President for signature.

Final action in passage of the budget usually occurs in September. Once the President has signed it, the fiscal year begins and work allocations are made. This is where we stand right now. FY-78 has already been allocated, as some of you know. Some of you are pleased and some of you are not so pleased.

Basically, this concludes what happens with the budget.

As far as what's going to occur next year--until we get the feedback from OMB and find out whether we are going to go with a pure zero-based budgeting system or something similar to what we have gone with this year, I really can't tell you what's going to occur. However, I think I can say two things fairly accurately. Minimum level programs will be redefined. This year we went on the basis that the projects with the least amount of funds for '77 were included in the President's

budget for '78, for sake of simplicity. The Construction Operations Division was going out to the field and using something like a 70 percent cut over the previous year's funding.

We will probably require manpower figures. If zero-based budgeting is instituted in its pure form, we will be prioritized with all the other construction general programs.

It's very important that we get good, concise justification sheets in. Not only for the budgetary process, but also to provide us with an idea of what exactly is occurring out in the field. It's a good education medium.

Many times we get a call from the Hill, from a Congressional Aide or, once in a while, even a Senator or a Congressman, wanting an answer. We can go to the justification sheet and give them an answer right then and there over the phone, and it has a much better impact then saying, "Hang on, I'll give you a call back. I've got to talk to the field."

Basically, we're fighting for an increase, but we're overshadowed by a great many other programs that, depending on how you look at it, do have a greater priority than this one since it's so small. But it's looking hopeful that at least our target level has increased over this year's funding.

As soon as we get the feedback from OMB, we'll give you some idea of the tentative level of funding that you would receive in '79, as far as the President's budget is concerned, so you can get with your Division and District Engineers and brief them on the situation.

A great deal of Congressional interest has been generated in some areas of the country, more specifically, Florida and Washington. We've gotten quite a few calls on that. This is what it takes. A lot of the country doesn't realize there is a problem, so it's vital that the public be made aware of this, through our efforts and through publicity. All I can say is--it's up to Congress.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC
PLANT OPERATIONS AND MANAGEMENT

by

Moderator - J. C. Joyce

It is a special privilege to be with this group of people. We are the people at the operational level that are charged with controlling aquatic plants. It is a very hard job to keep everyone in the field happy because you are never going to do that, but you also have a job to do. What this means is we spend a lot of time coordinating our programs with the local people, and after all, that is what the program is about.

The whole attitude of the Corps of Engineers had shifted this way. For a long time the Corps was a very arrogant organization, to be quite frank, but we have finally awakened to the fact that we are public servants. We have to make that man on the water happy and also do the job which we are charged to do by Congress.

This particular meeting is a unique opportunity for researchers and operational people to get together and talk about our common problems and possibly find a solution. We have a group of people, our researchers, who we are able to relate to on the operational level. We can tell them what the problem is and will be, and they will help us on their level to find a solution.

In the Jacksonville District we have attempted to do what we said we were going to do for a number of years--have a complete, integrated program, biological, chemical and mechanical. We are trying. We have had some success using chemicals, and this was through working with the local people, finding out what their real objection to the problem was and how we could best meet their needs and also do our job.

In '73 we had a problem in the St. Johns River. We initiated what we called a selective maintenance control approach, where we routinely monitor the river and hit the potential problem areas before they become problems. Construction of a new bridge also helped the problem because it has wider pilings and the plants will flow through it.

There is a world of difference between what the area looked like in '73 and today.

Our selective maintenance control approach works. I won't go through all the objectives of our maintenance control plan, but two key ones integrate other methods of control and reduce the environmental impacts of the overall program. We said that we would use fewer herbicides in our maintenance control program and we have.

We have spread the water hyacinth weevil throughout the state. The total now is about 54 locations on the St. Johns and about 32 in other parts of the state. The weevils are building up; they are spreading. Just about anywhere we go now, we can pick up a plant and, sure enough, it has feeding spots on it.

In 1972 and '74 there were a lot of waterhyacinths, and there was a lot of aerial application. This created a lot of hard feelings. It is going to be that way, if you have a massive infestation of plants and treat them with a lot of chemicals and a lot of plants die. It is going to put a heavy load on the water body.

Once we got it under control, the amount of acreage started coming down. Now we are reaching the level where it is going to level out with this approach. The level is now back to what it was in the 60's, but the problem is not nearly what it was in the 60's.

One of the key points of our control program is coordination with local people. Before you go in and do anything, ask the people what they want. We did this with our Orange Lake program. We went in and asked the people where they wanted fishing trails in Orange Lake. This is very important. Don't ever stop this contact with local people; they can help you.

We also monitor and evaluate. We routinely fly the St. Johns River, so we know where our problem is and where it is going to be. That is the key.

At Orange Lake, where we had over ten thousand acres of hydrilla, we needed to do something. We had a chance to lease a piece of machinery known as Aqua trio. We connected open water to the fish camps and to the people who live on the lake.

In summary, what we are attempting to do in the Jacksonville District is integrate all methods of control. Chemicals do have some adverse effects, and we are not kidding ourselves. But we feel once we get a total integrated program going, we can reduce the amount of chemicals needed. I hope we can reach the point where we never need them, but at this point we have to rely on them and we do. In the meantime, we are buying time until we can get a biological system, which is the thing everybody would like to work, on line and in operation.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC
PLANT OPERATIONS AND MANAGEMENT

by

Chester Martin

Aquatic plant control operational activities in the Galveston District consist of the control of waterhyacinth and alligatorweed. Although hydrilla has recently become a serious problem in portions of Texas, control of this species is not presently authorized as part of our program.

The Galveston District is a cooperative cost-sharing arrangement with the federal government and the State of Texas. The Galveston District represents the federal government, and the Texas Parks and Wildlife Department, under the supervision of Mr. L. V. Guerra, represents the State of Texas.

The state has been divided into 18 work areas for implementation of our program. Presently we are doing work only in ten of these work areas and primarily in the lower portions of these. Most of our work is within 100 miles of the Texas coast.

Hyacinth continues to be our number one problem in the State of Texas. Control measures for hyacinth involve the use of EPA-approved formulations of 2,4-D. Hyacinth infestations are presently most critical in the north coastal area and the Sabine River basin, both in extreme southeast Texas.

The San Jacinto, Trinity, and Nueces river basins are also problem areas which require extensive treatment.

We consider hyacinths to be essentially in a maintenance status throughout most of Texas, but it is still necessary to spend considerable funds annually to maintain the infestations at a minimum.

Infestations of alligatorweed have increased considerably in Texas over the past several years. There has been an expansion in the distribution of the species to the northeast and also to the west of the original localities.

The controlled acreage of alligatorweed has increased from

approximately 8400 acres in 1971 to 20,000 acres or so at present. The Trinity River basin and the north coastal area are the most critically infested areas at this time, although we do have extensive infestation in three of the other work areas.

Alligatorweed control methods to date in Texas have involved almost entirely the use of the Agasicles flea beetle. Although the beetles have been introduced in various localities in all five work areas since 1967, their weed destruction capabilities have been a limited success. No releases have been made since 1975 as part of our program. This is primarily due to the priority attached to waterhyacinth control and the general absence of funding for introducing new programs with alligatorweed.

There are presently some 2900 acres of hydrilla in Texas, whereas in 1976 there were only 1200 acres. According to Mr. Guerra, approximately 8300 acres are projected for Texas waters in 1978, so it is getting worse and worse. A 2000-acre area in eastern Texas at the Lake Conroe locality is presently our biggest problem.

Approximately 10 percent of the 21,000 acre lake, or approximately 2000 acres, is presently infested, and possibly 6000 acres or 30 percent of the lake is projected for the peak growing season next year.

Considerable interest has recently been generated to include hydrilla control as part of the Galveston District's program. In order to accomplish this task, our general design memorandum will need revision, and the environmental impact statement will have to be supplemented. Considerable effort and cost will be required to gather and synthesize the information for the study that is necessary to make the changes in these documents. However, the work allowance for our program is not presently adequate to support these activities, at least through Fiscal Year 1978.

Additionally, to our knowledge, we still have not identified an acceptable control technology for use on hydrilla in Texas that has EPA authorizaiton or has EPA approval for the herbicides and so forth. This is one thing I hope to discuss in detail at this meeting, to see if there are technologies available or methods for implementling these

technologies that we are not aware of, and that would perhaps shorten our job in taking time to apply these to the documents.

Although the Galveston District is presently under considerable pressure to include hydrilla control as part of our program, this does not appear to be attainable in Fiscal Year 1978 because of current technological and budgetary problems.

The Galveston District is interested in exploring all available avenues to initiate the environmental and economic studies necessary to include hydrilla as part of our program. It will first be necessary to obtain additional funding to accomplish these tasks. We also wish to pursue the possibility of an expanded research program on hydrilla in Lake Conroe as soon as possible. Such a program could be effective in reducing at least a major portion of the present infestations on the lake. We are also interested in procuring additional funding for a technological transfer project at Lake Conroe in Fiscal Year 1979.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC PLANT OPERATIONS AND MANAGEMENT

by

W. E. Thompson

The New Orleans Districts involvement in aquatic plant control goes way back. In 1897 Congress requested that the Corps of Engineers furnish a report on the problems being caused by waterhyacinths in the southeastern United States. The report which was submitted in 1898 indicated widespread infestations of waterhyacinths in Louisiana.

Some of the infested rivers were the Sabine--this is on the far western side of Louisiana; the Calcasieu, which would be just a little further east; the Mermentau, which is a little further east yet; the Atchafalaya, which runs pretty much down the center of Louisiana; and the Grand Amite, Tangipahoa, Tchefuncte, and Tickfaw, which are in the area just north of New Orleans and flow into Lake Pontchartrain, the big lake just off New Orleans.

The bayous which were infested were Vermilion, which is over in the southwestern part of the state; the Teche, which runs through the center of the state almost parallel to the Atchafalaya River; Bayou Plaquemine, which was one of the navigable waterways, from the Mississippi down through Morgan City into the Gulf of Mexico; Grosse Tete, which is up in the same general area north of Baton Rouge; Barataria, which runs south from Lake Pontchartrain in the New Orleans area into the Gulf; and Bayou Manchac, which runs between New Orleans and Baton Rouge, or between Lake Pontchartrain and Baton Rouge.

The lakes which were infested were Grand Lake, which is in the Atchafalaya Basin, sort of in the south central part of the state; Chicot; Lake Pontchartrain, which is the lake just north of New Orleans; and a lake which they call Manchac, which, since there isn't any Manchac Lake, I assume is Maurepas, which is connected to Lake Pontchartrain on the west side.

At that time--in 1897--they said Vermilion Bay and Cote Blanche

Bay were both infested. These bays are in the south-central part of the state.

The report went on to say, "No definite statement has been made of the length of time that the streams in Louisiana have been affected. It may be stated, however, that one of the members of the board" -- and the member that they were referring to was a Major Quinn -- "when in charge of certain river and harbor improvements in Louisiana," some 20 years before the report was written, which would be the late 1870's, "had the plant and its peculiarities described, and it is believed it was then flourishing in the Atchafalaya."

If you remember your waterhyacinth history, most reports note the waterhyacinth as being introduced at the Cotton Exposition in New Orleans in 1884. Well, this Major Quinn had the plant described to him sometime in the late 1870's, so obviously the plant was in Louisiana before 1884. I feel sure that the plant was exhibited at the Cotton Exposition, but it was probably in Louisiana long before that, as evidenced by the widespread location of waterhyacinths throughout the state at that time, and by the fact that most of the infested bodies which were mentioned are not connected. There would have had to have been quite a transportation system over a very short period of time to affect all these lakes.

As a result of the report which was submitted to Congress, $36,000 was appropriated for the State of Louisiana and an additional $36,000 for the State of Florida. Of the $36,000, $25,000 was to be used for the purchase or construction of a boat for crushing the plants. They ran a number of studies and decided that crushing the plants was probably the most economical and most suitable way of getting rid of them at that time. $1000 was allotted for construction of log booms to prevent the plants from leaving streams and infesting other streams. $10,000 was allotted for conducting operations.

The first actual control work was done in April of 1900, when a boom was constructed across Bayou Teche. This was a sort of floating or fixed boom, which was constructed to prevent the plants from infesting Bayou Pierre Part, the Pierre Part area.

The ninth of July, 1900, the crusher boat was completed and began operating, and it operated until the first of June, 1901. It operated 11 months, when the funds which were allocated ran out, and then the program was shut down. The same type of operation was authorized in Florida, but Louisiana's experience with the crusher boat indicated that this method was too slow and too expensive to be practical.

The crusher boat was converted to a spray boat, and in September, 1902, a spraying program using sodium arsenite was begun. In 1912 spraying costs were estimated at thirty-seven cents per square yard, a little less than $18 an acre. At that time, they felt this was a reasonable price.

We haven't progressed a great deal. We still have trouble controlling the plants from a boat-type spray for the same amount of money, although we can control them from a helicopter for about half that, I think.

The program continued, using the arsenite spray, until 1938 when arsenite spraying was discontinued and the program reverted to crushing and removing plants by conveyors and constructing booms.

In 1941 the use of sawboat-type destroyers commenced. These ran over the plants and chopped them up into little pieces. The conveyors had to handle the plants twice, pick them up and then discharge them. This was an economy move which was made to bring the price of control down and also speed up control operations.

Use of a crusher boat in conjunction with conveyors and sawboat destroyers continued until the late 1940's when 2,4-D was developed and became available. 2,4-D is the control program that we have been following since that time and has permitted a much more mobile field control operation. It continues to be the control program which we use.

Recently we had eight aluminum welded boats built. They have an outboard motor and spray pump, and an air-cooled gasoline engine.

Over the last couple of years we have changed from 10-gallon-a-minute pumps to 20-gallon-a-minute pumps. Use of the higher capacity pumps allows us to cover areas a little quicker and use a little higher

spray pressure, which has increased the throw or distance which we can reach with the spray.

We started using Dema injectors a couple of years ago to meter the chemical from the chemical concentrate tank into the spray system. It has a screw arrangement by which you can increase or decrease the amount of chemical in the spray. We feel that it is a little bit better system than the use of the metering discs, in which the whole disc has to be taken out and replaced with a disc of a different size.

We have also gotten a little smarter in the last year and borrowed from Florida some of the techniques that they have been using for several years. We use two airboats, which have allowed us to get into shallower water areas and into some areas which have submersed weed problems which had given our outboards a real problem.

We also have under construction two mudboat type boats. These boats should allow us to push through areas where hyacinths are jammed and where we can't get through with our regular outboard boats. They have quite a bit more power than you can generate with the outboard and allow us to get through some areas where we have trouble getting in with our airboats.

For the past year the Louisiana Department of Wildlife and Fisheries has been utilizing a sort of lease spraying contract where they furnish the 2,4-D and the contractor furnishes a fully equipped helicopter and service truck. They have found this to be very effective. They have been able to move their operations from one infested area to another area very quickly, allowing them to spray quite a bit of area quickly. In fact, I think they have gotten as many as 800 acres sprayed in one day with this type helicopter, a Bell Jet Ranger.

This year has been very rough on the alligatorweed flea beetle. We have had a very difficult time finding evidence that the _Agasicles_ has survived our winter in any great numbers. Just within the last week or so we have found that we do have some populations starting to build.

About a month ago, however, we found a pretty good infestation of the stem boring moth _Vogtia_, which has survived very well through the winter in Louisiana and is found in all locations where we have

alligatorweed. It is doing very well, although the evidence of the moth is rather subtle. You may see some stems of plants against the water edge which are drooped, lying down on top of the other alligatorweed. This is a pretty good indication that the larval stage of *Vogtia* is present.

Alligatorweed has made a comeback this year, but not to the extent that it is really a problem. There has been more alligatorweed than any time since 1972, when the flea beetles first were found in Louisiana.

Even though the flea beetles have had a hard winter, in some areas we have nevertheless had a pretty good reduction in alligatorweed.

One of the new systems which we are working on with the Waterways Experiment Station involves a nursery area of waterhyacinth weevils, *Neochetina eichhorniae*. During the last year, Louisiana Wildlife and Fisheries has moved more than 40,000 adult insects from this particular nursery area.

Weevils and pathogens have also been introduced in combination by the Waterways Experiment Station as part of a large-scale operations mangement test on waterhyacinths in which we are cooperating with the New Orleans District.

We are testing a marsh-buggy type machine to see if it will give us access to some areas which are presently inaccessible. It is possible to equip the machine with a cutter bar across the front to cut marsh or submersed vegetation.

We have a submersed weed problem in Lake Boeuf--*Egeria densa*, Brazilian water weed.

Lake Theriot, a 1500-acre lake, is rapidly filling with hydrilla, which is taking over from Eurasian watermilfoil. You "trade the devil" for something else. We hope sometime in the near future to begin doing some work on the submersed vegetation, but with the manpower and money limitations, we haven't done very much yet.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC
PLANT OPERATIONS AND MANAGEMENT

by

Ed Moyer

In the Corps of Engineers Fort Worth District we have 17 reservoirs. On 15 of them, we really have not done any type of aquatic plant control work at all. Some of these reservoirs were built during the period 1947-1965. These represent about 145,000 surface acres. The two projects on which we do have aquatic weed problems are the Sam Rayburn Dam and Reservoir, and the small reservoir below that, the Town Bluff Dam-B. A. Steinhagen Lake. What we have here is waterhyacinth and some alligatorweed.

Essentially, Lou Guerra of the Texas Parks and Wildlife Department does the entire aquatic spraying program for us, so we are in more or less of an adminstrative program in operations. We had arranged a 70-30 cost-sharing program with the state to do this job, and they have done it very successfully in the past two years.

Along with that, we have much lower elevations at Sam Rayburn Reservoir. This seems to be helping to keep the aquatic population down, but of course these things might just be seasonal and we might have them back next year.

Concerning the entire reservoir district, the climate and topography vary considerably. As our district reservoirs are scattered about the state, we do run into variations which affect the reservoirs and indirectly the aquatic weed growth.

If we look at the district reservoirs in the western sector of the state, we find with few aquatic plant problems, because here we have a lake elevation about 10 to 25 feet below the designated conservation full top. What we do have here, instead of aquatic vegetation, is such trees as mesquite and salt cedar. They get into these basins, from a couple hundred to a thousand acres, and they actually have to be root-plowed out. We have had fires in these dry lake basins. We actually

even open them up for motorcycling. Needless to say, in this particular part of our state and our jurisdiction, we don't have any problems with aquatic weeds.

As we proceed eastward we run into two large river systems, the Trinity River system and the Brazos River system. They run in a northwesterly to southeasterly direction in the state for a couple hundred miles and deposit into the Gulf of Mexico. We have six reservoirs on each of these projects, and we really don't have a whole lot of problems here. We have got a lot shoreline emergence, some pond weeds and such, but we have never had a major aquatic plant control problem on any of these reservoirs.

We have instances where we have a low lake elevation in the springtime. Maybe there is a drought problem going on in the state. If this lake elevation is held down for the spring and the summer, we will eventually get some watermilfoil problems, which has occurred in a few reservoirs. Once the reservoir elevation got up again, it seemed to die out. We actually had a case where we bought some chemicals and we had to give them away because we never had a chance to use them.

In these reservoirs on the Trinity and the Brazos, we have some particular type situations. One of the situations is that we have reservoirs located in the black clay lands of north-central Texas where a lot of cotton grows in these areas. These reservoirs are open to the wind and they have hardly any type of aquatic vegetation. This is primarily due to the clay colloidal suspension in the reservoirs. During erosion it washes in, and these lakes are in a turbid condition nearly all the time. We have actually had to go in and put some underwater fish shelter or fish attractor beds for fish habitat, because there is no underwater profile at all. We have just a few pond weeds around the edges.

We also have situations in some of the reservoirs where the shorelines are rather steep with no gradual sloping to them. Many of these are limestone-type caverns or bluffs, or just rocky type habitat. These are generally deep reservoirs, and again, we don't have very much problem there at all.

Perhaps the biggest problem we have in the reservoirs of the Fort

Worth District Corps of Engineers, as far as environmental impact, is woody growth. We have in some instances up to 35 or 40 percent of the entire shoreline with cottonwood and black willow trees and buttonbush, that we sometimes have to remove.

The Texas Parks and Wildlife Department has gone out on our reservoirs doing their annual fish surveys. They probably do the most comprehensive job as far as estimating the type and density of the aquatics we have. I have just finished reading most of their reports, which indicate about one-tenth of an acre in pond weeds. They will get up to about 20 or 30 pounds of American lotus or things that don't really cause a whole lot of problems.

As I said, the main impact in our area is the woody growth, in 15 of the 17 reservoirs. Some of the plants on these 15 reservoirs are the American lotus, spikerush, broadleaf pondweed, Sago pondweed, bushy pondweed, water purslane, marsh saltweed, chara, cattail, softstem bulrush, giant cane, various sedges, water pennywort, squarestem bulrush, maidencane, Wolffia, slender spikerush, softrush, arrowhead, loosestrife, water primrose, primrose willow, black willow, buttonbush, and water willow.

The remaining 127,000 acres is represented by Sam Rayburn and Town Bluff, and is over in the east-central part of Texas, near the State of Louisiana. Here we run into our problems with aquatics, namely the waterhyacinth and alligatorweed. In '74 we went in to a 70-30 cost-sharing program with the Texas Parks and Wildlife Department.

Let me read from a recent report on the projects. I am quoting now: "In 1974 a cost-sharing agreement was entered into between the Texas Parks and Wildlife Department and the Corps of Engineers to control noxious aquatic weed species on both reservoirs. Actual work began by crews of the Texas Parks and Wildlife Department late in 1974 and has continued until the present." (That was about the beginning of this year.)

"With the efforts of the cost-sharing program, waterhyacinths have been controlled and contained to several small areas in both reservoirs. Acreage of waterhyacinth at Sam Rayburn has been reduced from 2000 acres

in '74 to less than 500 acres at the present time. Acreage at Town Bluff has been similarly reduced."

"Control of aquatic weeds at both projects has been enhanced by prolonged reductions in water levels and by several instances of hard freezes that have helped to control the noxious species. In conclusion, it appears that the cost-sharing program is the answer to the problem at both projects. If the program is continued, it should effect full control of waterhyacinths at both projects in the next two or three years."

I disagree with that last statement. We have gotten about 60-70 inches of rainfall in this area and we have warm temperatures most of the year round. Some of the areas are relatively clear. We have got low mean average depths, and we have several hundred or a thousand acres or so of various inundated timber where these aquatic weeds can hide and come out during the flows from upstream.

Previous to the Texas Parks and Wildlife contract, we had spraying of invert emulsion of 2,4-D. This was done by separate contracts with various chemical corporations and was an aerial invert application. Lou Guerra and his crews now work on the lakes a much longer time than the two-week period, generally with the helicopter, and they can get to the impact areas quicker and can continue over a longer period of time. It looks really good and the project personnel are well satisfied with it.

In regard to the actual checking up on aquatic weed growth in our reservoirs, we in the Corps of Engineers do not have an program whereby we send some of our project personnel out on the reservoirs and survey them, what you would call a comprehensive survey. For the most part, as I said, the Texas Parks and Wildlife Department helps us out quite a bit with the fisheries crews and the lake rangers out in the reservoirs. They will pick up most aquatic infestations and we get word about it.

One further point I would like to make concerns decisions for spraying programs. I or no one else in the District goes down to Sam Rayburn Reservoir, say, and tells the project manager, "This is how much money you are going to spend on this particular program and here is where you are going to spray," and all this. They submit out of their

O&M budget a line allocation each year for so much in aquatic plant control.

For example, Mr. John Letney, the reservoir manager, has lived and worked at these two projects for about the last 20 years. I don't feel that I can go down there and tell him just how to manage his particular problem, because he is well aware of it. Each year we keep a maintenance type approach to control of the aquatic weeds. I think the project personnel, if you would go down and ask them right now, would tell you that their reservoirs are as clear as they have ever been in the last few years. As I said, they are quite happy about it.

Thank you.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC
PLANT OPERATIONS AND MANAGEMENT

by

M. J. Griffith

I am from the Seattle District. Our main concern in Washington State is Eurasian watermilfoil. The problem is in its early stages and unlike almost everybody else I have heard here, we don't have an operational program under way. We have just started the study phase this year.

We really see two different types of problems. One, in the Seattle area, is a known milfoil problem. The second type of problem, in the eastern part of the state, involves a threat to the Columbia River from major infestations of milfoil up on the Canadian Okanagan River.

We have salt water on the left side of Seattle in Puget Sound, and freshwater lakes on the right side. There is a Corps of Engineers lock that provides passage to freshwater harbors in Lake Union and Lake Washington. There are also a number of small, isolated water bodies in this area.

The worst problem area right now is in one arm of Lake Washington, called Union Bay. The problems were noticed here about three or four years ago. They are now intense enough that local citizens have organized groups like Save Our Union Bay Society. They are going around, getting $100 a head from their neighbors to try and do something, although they are not quite sure what, to stir up interest.

The area from Lake Washington through the Union Bay arm of Lake Washington, out towards the locks in Puget Sound is called the boating capital of the world. That is probably going to help spread the milfoil to all the lakes that don't have it now. A local study shows that about 20 percent of the lakes in this Seattle metropolitan area now have Eurasian watermilfoil.

The other type of problem is a prevention type of situation. There is a chain of reservoirs up the Columbia River, involving navigation and hydropower. In fact, there is navigation clear across

Washington over into Idaho. These are mainly Corps projects, and some private projects, to which there may or may not be a threat that you could compare with the TVA situation a few years ago. There are major infestations up on the Okanagan arm, which started in Lake Okanagan in 1971 and spread down the Okanagan River.

Control program costs have escalated. I think they are between one and two million dollars. I understand that tomorrow there will be further explanation of what the Canadians are doing in their control methods. Most of the Canadian efforts have been mechanical. It was only this last year that they have begun to use 2,4-D.

The weed continued downstream. The Canadians tried to put in about four barrier structures with a wire net underneath to try and stop the spread toward the U. S., however, the eddy currents on the downstream side were a problem. They estimate these barriers are about 80 percent effective.

The weed is moving downstream at about a half a lake a year, I guess you would say. In '75 it was found in Lake Vaso. The next lake downstream, the north end of Lake Osoyoos, which crosses the border, had it in 1976, and, guess what, this year the south end, the U. S. side.

We have been quite fortunate, I would say, to have been made aware of the program in the early stages. Half of it is due to the Canadians who have brought it to our attention, and the other half is that in the Seattle area there is a planning group which made the only other good study that has found milfoil in several lakes. It has become a high priority item for the state.

Just this spring we were asked to do something, so we started our process and said we would work as fast as we could. The state agreed and said they would then undertake some control operations under our guidance. Then we would lean on the people from Vicksburg for their expertise.

The state hired a local milfoil man. He has a weekly newspaper article in the paper and a weekly radio show. The parks people are putting up posters around the area and are also doing surveys out in the lake, looking for the weed. This works for the large patches, but

individual weeds are best found by a diver. If they find a weed patch or even enough weeds they can't pull by hand, they anchor a block there. If it is a fairly large area, maybe 100 feet long and 10 feet wide, they block it off to keep people out.

The state now has approval for this fellow in Oroville to use 2,4-D. We had a meeting with all the state agencies, fish and game and so forth, and everybody agreed this was somewhat of an emergency to try and stop Eurasian milfoil at Lake Osoyoos.

They have put in a barrier structure at the outlet of Lake Osoyoos, like the Canadians used. They have got a few fragments of milfoil, but it will keep coming down from Canada, that's for sure. They will have to take these things out, though, because of freezing conditions.

Assuming the weed goes down the Okanagan River, the first reservoir it hits is Wells Reservoir on the Columbia River. Then, as I say, there might be a threat that could be comparable to the TVA system of reservoirs. Also, in eastern Washington there is an extensive irrigated agriculture development.

So, to summarize, we have two types of problems. The one in the Seattle area is partly a combination of prevention, maintenance, and control. The problem on the east side is more a prevention type of problem. The public is very much aware. I was happy to hear today that Washington was one of the two states whose weed problems the people in OCE have been hearing about from the Congressional delegation.

The important thing is that in April of this year, the state asked for our help. Then we had a meeting with all those involved, including the EPA and the people from Vicksburg. We established timetables and the work to be done by everybody. The state agreed to undertake some of these actions, like the survey in Wells Reservoir and the actions on Lake Osoyoos, in consultation with us and in anticipation of a future cooperative program with the Corps of Engineers.

We held two public information workshops in the Seattle area and in the Oroville area this summer. We had Dr. Sanders from Vicksburg as the featured speaker at those. We have a state letter of sponsorship, and we just submitted our reconnaissance report last month.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC
PLANT OPERATIONS AND MANAGEMENT

by

Mike Eubanks

The Mobile District is large and has portions of six states. Starting on the western side, we have a small portion of Louisiana, a good bit of the state of Mississippi, most of the state of Alabama, just a fringe up in Tennessee, about half of Georgia, and the panhandle portion of Florida.

The Mobile District is made up of seven major river basins, which are the Apalachicola-Chattahoochee-Flint, the Choctawhatchee-Perdido, the Escambia-Conecuh, the Alabama-Coosa, the Black Warrior and Tombigbee, the Pearl, the Pascagoula, and numerous coastal streams in between.

The major weed problems, however, are almost confined to the southern half of the District in the coastal plains, but we are aware that species such as Eurasian milfoil and hydrilla not only are found more northward but definitely have the capability of infesting the waters in the northern portion of the District.

As best I understand, there are three separate programs under which aquatic plant control is carried out in our District. Two of them are O&M. The one O&M, the 1899 authorization, is for the removal of waterhyacinth from navigable streams. The other O&M project is within the boundary of Corps projects to maintain authorized purposes, such as some of ours at Lake Seminole. This is the type authorization they are operating under for the control of such plants as hydrilla and Eurasian milfoil. The third authorization is the cooperative program in 1965, Public Law 89-298.

The 1899 O&M program is carried out through the Mobile area office of the Corps of Engineers, with spraying for waterhyacinth done mainly in the Mobile River delta right above Mobile. So far this year they have sprayed 957 acres of waterhyacinth, primarily in the Mobile River delta, and every now and then when the problem arises they will also go into

coastal Mississippi and the Pearl River portion of the State of Louisiana, along by some of our projects in the Pearl River.

Under Public Law 89-298 we currently have two active programs, one in the Florida portion of the Mobile District and one in the Louisiana portion. The one in the Florida portion is carried out by contract, which the Jacksonville District currently has with the Florida Department of Natural Resources. Previous to July of this year, it was with the Florida Game and Fresh Water Fish Commission. So far this year, through August 1977, a total of 2410 acres of waterhyacinth have been sprayed. Surveys in 1976 put the acreage at 3586 acres of waterhyacinth in the Mobile District portion of Florida.

Also, a big increase in alligatorweed has been noted. There has been decreased or very slight beetle damage to alligatorweed thus far this year, and increased amounts of alligatorweed throughout the District, not only in the Florida portion, but in Alabama and Mississippi, as well.

The program with the Louisiana Department of Wildlife and Fisheries reported spraying a total of 1450 acres of waterhyacinth from July of '76 to June '77. 1976 survey revealed about 1050 acres of waterhyacinth. As we were talking about this morning, it is hard for some people to see that if only 1050 acres are reported, how could you have sprayed 1400 acres. But being involved in the weed control business as we all are, we know that often happens.

Using the phraseology of the OCE, talking about "opportunities" in aquatic plant control, I feel that we have one of the biggest opportunities in Lake Seminole. Our reservoir manager, Angus Gholson, has done an excellent job in keeping up with the weed dynamics in Lake Seminole. They have cataloged over 600, I think close to 700, species of aquatic and marginal type plants at Lake Seminole. The four major problem plants are waterhyacinth with 800 acres, hydrilla, 1000 acres, Eurasian watermilfoil, 8000 acres, and giant cutgrass, 4700 acres.

The size of the reservoir is about 37,000 acres. Some of the characteristics that make Lake Seminole ideal, as far as aquatic plants go, are the local and upstream sources of plants, favorable temperatures,

long growing seasons, nutrient-rich waters, favorable pH, variable water chemistry in the different arms of the reservoir, large areas of clear shallow water, and extensive inundated, uncleared areas within the reservoir.

This 20-year-old reservoir has got almost any kind of aquatic plant you'd want to find. As far as the chemical people, we are always interested in putting out plots and there are many plots now under observation.

The Waterways Experiment Station, as mentioned earlier this morning, is experimenting with their aquatic plant management plan approach, thus working toward a situation for controlling aquatic plants in a certain area. We appreciate their efforts and we feel that this will be a good test for the program because it is a complex problem. We have had trouble getting the results at Lake Seminole that some people have gotten elsewhere, especially on hydrilla and giant cutgrass. We really haven't anything we can put our hands on right now, other than six to eight weeks' results on these two plants.

We have the final EIS and design memorandum for the coastal Mississippi cooperative program, which we are working on with the Mississippi Marine Resources Council, principally for control of waterhyacinth.

In doing the reconnaissance survey for the State of Mississippi back in '75, we tried to locate some of the problem areas and to run down some of the history of how they got started. We found a waterhyacinth infestation in the "boondocks" of southern Mississippi in a little gum pond area. We went to a nearby general store to try and find out how a waterhyacinth infestation could be out in the middle of nowhere, probably 100 miles from the nearest large infestation. Come to find out, there used to be a really good bream fishing place there, and the fellow that owned the land stopped the fishing in the area. So someone who used to fish there introduced a waterhyacinth and said, "Well, if I can't fish there, nobody will!" That's how that got infested.

At a farm pond near Waynesboro, Mississippi, I saw something out in the middle of a pasture that immediately caught my eye. I went to talk to the owner. Come to find out, she had bought three waterhyacinth

plants in Pensacola about ten years ago and put them out there, and she thinks it is great. She has been giving them to everybody. I tried to explain to her that this is a noxious aquatic plant that can cause problems. I didn't get too far, but I tried, anyway.

I also found an infestation in a gravel pit near Hattiesburg, Mississippi, but I wasn't able to find out how it occurred. Probably something similar--for the beauty of the flower or something.

We had an unusual infestation in the summer of '75, a tremendous bloom of Spirodela. The problem no longer exists and had very unusual circumstances. I am not sure exactly what all went on that summer to cause the problem.

In 1975--that was a good year for aquatic plants--we picked up milfoil in the Mobile River delta. It is just growing by leaps and bounds, and we haven't been able to make headway as far as a cooperative program with the State of Alabama is concerned.

Along the coast, at Pearlington, Louisiana, for example, we do have a lot of problems with water primrose.

WES worked with us in the Brickyard Bayou area and introduced the waterhyacinth weevil. It has also been introduced in the Louisiana portion of the Mobile District, in Lake Seminole, and in various other areas around the Florida portion of the Mobile District.

As I said, we have had almost a minimal population this year of the flea beetle, and a dramatic increase in the alligatorweed districtwide.

There is evidence of slight Vogtia damage in some areas, and it appears quite common throughout the coastal region of the District.

We have tried a new application technique on hydrilla and also on Eurasian watermilfoil. On both we use a granular material. On the hydrilla we use Hydout, and on the Eurasian watermilfoil, Aqua-Kleen, the 2,4-D BEE, using a fixed wing aircraft to put out the granular material. This proved very effective in applying the material.

There is a unique situation at Lake Seminole. We have tremendous problems with giant cutgrass blocking off channels and coves, and the coves filling in rapidly, creating a terrestrial environment.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC
PLANT OPERATIONS AND MANAGEMENT

by

Jim McGehee

I would like to preface what I am about to say with a kind of disclaimer, to say that what I am talking about are mechanical control efforts that apply only to Orange Lake. With each situation, each lake, these are going to vary, I am sure, quite a bit.

We wanted to give you the most up-to-date information we could, so we set a cutoff period, September 23, to bring you the benefits of our latest reports on the operations.

The Waterways Experiment Station did some work for us last year. We sponsored it, and they did the work with mechanical control systems. As part of that, they looked at mechanical control of hydrilla, at Orange Lake and at Withlacoochee River.

We looked at the results they had gotten at Orange Lake, and they looked very favorable. So, this year we figured we would go out and put it on a truly operational-type basis. We started thinking about whether we were going to control hydrilla or if we are going to work with it and try to manage it in the situations we have in the State of Florida.

Orange Lake is a 12,000-acre lake and has got an awful lot of big bass in it. We started looking at the numbers of fish camps and related businesses that were around Orange Lake, and we wondered if there was enough benefit to justify treatment of the entire lake with what we had available to do it with.

The answer we came up with was no. There was no way in the world that we could financially justify--come up with a favorable cost-benefit ratio--treatment of Orange Lake, either mechanically or chemically. It would just cost too much money, and there weren't enough benefits to offset it.

So, we asked what was the next best thing. We have got to help the people out there; they definitely have a problem. We started looking closely at what they could possibly use, and we started talking in terms

of not controlling or trying to eliminate all of the hydrilla, because we couldn't justify that.

So, we went out to the people, as a part of our program. We said, "We want to help you. We can probably make some trails for you to get around. We can probably cut some open areas for you to fish in. Where do you like to fish and where would you like to go in the lake?" We came back with a composite.

The people with the State Game and Fresh Water Fish Commission worked with us in talking with the people there. Mr. Joe Henkel, who works for the Game Commission, knew pretty much what they were looking for.

Based on the productivity of the machinery from the year before, we came up with something we thought would be workable. I have some data I want to give to you that looked very encouraging to us, in terms of using mechanical control systems in certain water bodies.

We also looked at it from an operational standpoint, in terms of contract time. We asked how we were going to do it. Were we going to pay the guy by the pound of hydrilla he hauls out? Are we going to pay him by the hours he operates? How are we going to do it? We figured it would probably be best, to our advantage, to work on an operational hours basis. This is the way we worked this contract out, on a leased-plant basis, where we pay the contractor to furnish all the equipment, all the personnel, all the supplies, and everything that was needed in order to do the job for us on an operational hour basis.

We broke it down into three basic types of payment unit prices. One of them was for operational time, one of them was for lay time--lay time was the time the guy was out there and couldn't operate, but since he still had fixed costs, we paid him at a certain rate--and one for lost time, when he was not operating, for which he did not get paid.

This is an incentive for a contractor to keep that machine moving, which we were looking for.

One of our "opportunities" is Orange Lake. We had some different densities in the lake, as we found all over the state of Florida. In some places hydrilla grows better than in others.

During the period of record for our work on Orange Lake, 20 June to 23 September, we found that one truckload of harvested hydrilla weighs anywhere from a ton to a ton and a half and within about a week's time would reduce in size to about 18 inches. That is where it stays for almost a year, although it might go down to about 12 inches.

At a disposal area on the land about a month after we placed the material alongside an orange grove, the grass had grown about eight to ten inches high.

When we went there, we had good intentions of taking out the material that we cut, but we had some problems. We had low water in the state of Florida this year. Orange Lake for some odd reason just seemed to go down faster than anybody could keep up with. At the transfer points (the land-water interfaces that we had found and that the real estate people had helped us get), the water became so shallow that we couldn't bring the equipment in. The local people were saying, "Hey, you know you guys are hauling that stuff out of the water, and you may be running a mile or a mile and a half when you could just put it over to the side of the lake and be done with it and get better production." We decided to try that, and it worked out quite well. It increased our production considerable, and we found that there weren't that many apparent adverse effects.

We consider the situation as one of taking the plants out of the areas where we don't want them and localizing any problems we would have with decomposition of the plants by placing them as far as we can to the side.

The trails we cut ran as much as two and a half miles in length. We tried to place them where they would be adjacent to the bonnet beds and at places that were favorite fishing spots, so the people in the area could have access without our having to cut additional trails. Wherever we found open water, we tried to make use of it. If there were long streams of open water, we cut along there rather than cutting through the heaviest part of the material, because it is cheaper to do it that way.

To open up use areas for fishing, we just cut back and forth until we had a big square.

I would like to throw some numbers at you that may be kind of interesting. The period that we are talking about, 20 June to 23 September, 1977, was a total of 96 calendar days. Of that amount, 69 were days on which we could perform work. In other words, they weren't weekends; they weren't holidays. The actual number of days on which no work was accomplished when it could have been was five, which I think is phenomenal.

The thing worked out really well. The total number of full, eight-hour workdays we had was only 24, but of the total time we did work, the average number of operational hours per day was 6.3. We did not have the usual summer rainstorms and all that we expected, so that helped the situation an awful lot. Of course, the lost time during the eight-hour day averaged 1.7 hours.

As for actual work performed to date, 23 September, we cut 112,000 feet of trail. These were four-width cuts. In other words, we took an eight-foot cutter through four times, for an approximate 30-foot cut, 32 feet wide. This relates to 21 miles of trail, or in terms of acres, 83 acres were cut and maintained for the full period.

We opened 13 separate use areas, which went from the largest, eight acres, to the smallest, one acre. They were mostly two to three acres in size, for a grand total of approximately 45 acres in the use areas, or an overall total of 127 acres. That doesn't sound like an awful lot, but there were a lot of people out there using it, catching quite a bit of fish and doing quite a bit of good with it.

We then get down to the nitty-gritty of how that compares with trying to do the work by other means, and we get to the cost factor. We paid the contractor approximately $4200 mobilization and demobilization. That was for him to bring his equipment to the job and take it back home. In addition to that, the total cost of operations for the period of record was $50,861, for a total cost per acre value of about $400 per acre, for maintenance for nearly the full growing period.

I would like to ask, though, where we go from here. WES cranked

things off and got it going for us really well last year. We took what they did and put it together with what we thought was a pretty good plan. Of course, we had to make some changes in midstream that worked out even better. We found out that we could do a better job than we thought we could, and after we look at it now, we find that we can probably do an even better job.

We found that the people in the field that were working with us did a really good job for us, though maybe were recutting a little bit too soon.

We found that we had to recut some areas within a month's time. Some of them we cut once, and we never had to go back for the period of record, 96 days. A lot of that we don't completely understand, but we have a pretty good handle on it. If we go to Orange Lake again next year, we know what we can do for the people there with that particular piece of equipment.

We also found that we could probably come up with some cost reductions. We dumped about 62 percent of the material on the land (actually took it out and put it on the shore) and put 38 percent of the material out somewhere in the lake, along the edges. This surprised us. We thought that more than that was put into the water. If we had put all of it open water areas, we could have come out with a much cheaper cost per acre, using the same pieces of equipment except those that were needed to take it up on the shore and to the disposal area.

We come up with a total figure of $273 per acre. Of course, this again is tentative. We should be able to increase our production to cover probably 150 or 170 acres, I would imagine, on a maintenance situation. It is very possible that the Jacksonville District may be using this same type of equipment or system in the future for some of this work.

Thank you.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC
PLANT OPERATIONS AND MANAGEMENT

by

John Carothers

The Charleston, South Carolina, District, also includes a large part of North Carolina and a small area in Virginia. The cooperative aquatic plant control project includes only the South Carolina portion.

Our project began in 1960 with an effort to control alligatorweed in the Santee-Cooper Project. Santee-Cooper is a state hydroelectric project which includes two very large, shallow reservoirs which cover an area of approximately 250 square miles. Work under this contract was terminated in 1967 because of a lack of funds and a greater need for work in other areas.

A new contract was negotiated in 1967 which provides for aquatic plant control in all state waters except for the Santee-Cooper Project. Initially, five streams were designated for control work. These streams are generally quite small, clear water streams, which are primarily used for fishing and other recreation. There is no commercial navigation involved.

Control operations consist of the use of 2,4-D and insects. When 2,4-D is used, one spray crew works approximately six week to three months, depending upon the extent of infestation.

During the first four years of work on these streams, thrips and flea beetles were released at various locations. The thrips apparently did not become established. The flea beetles have become established and their abundance fluctuates tremendously with the season. I have never been able to find any sign of flea beetles during the spring, but usually by August they become quite abundant, except for this year. We haven't been able to find any at all, even up until the middle of September.

A few years later the U. S. Department of Agriculture released the stem borer. This insect has become established but it has never reached the abundance achieved by the flea beetle.

When work began on these streams in 1967, alligatorweed infestations were quite bad and severely restricted any use of these streams. I have been in the Charleston District for six years, since 1971, and based on my somewhat limited observations, alligatorweed has been steadily declining during that period. I have never seen alligatorweed infestations similar to those in photographs taken during the 60's.

In 1975 we discontinued the use of 2,4-D because it was not registered for use in moving water. Periodic observations since that time indicate that alligatorweed has continued to decline. Since we have no significant problem with alligatorweed, the only action that we plan to take is to restock the beetles.

Recently another exotic plant has replaced alligatorweed as the major aquatic plant problem in South Carolina. A major infestation of this plant, egeria, occurs in Lake Marion, which is one of the two lakes in the Santee-Cooper Project. It was first reported in Lake Marion in 1965 and it rapidly expanded until by 1974 I estimated the infestation to be on the order of 10,000 to 20,000 acres.

Primrose tends to overlay the egeria. Another area of major infestaton is the Cooper River and its tributaries and adjacent rice fields.

The Public Service Authority, which is the state agency having the responsibility for administering the Santee-Cooper Project, has asked that we include the Santee-Cooper Project in our cooperative aquatic plant control program. In response to this request, we have just completed a survey and are preparing a report on the status of elodea in South Carolina. When completed, this report will assist in the consideration of the state's request for assistance.

Thank you.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC
PLANT OPERATIONS AND MANAGEMENT

by

Clydes Gates

First of all, let me explain that Little Rock District has no active control program going. The alligatorweed, which was the original problem in Arkansas, is technically under the authority of the Vicksburg District. The State of Arkansas is under no cost-sharing with them. Therefore, all we do is monitor.

As far as the Little Rock District goes, I am coordinator for aquatic plant inspections.

Since I am in a reporting status and do file claims and such, that is what we will be looking at today.

We have a number of areas on the lower Arkansas River where alligatorweed has been a problem. One of these is a coal pile at Pendleton Bend on the Arkansas River. The stem borer infestation there has been rather prominent this year. The severe winter we had over the past season, followed by the long, hot, dry summer knocked the alligatorweed back. The stem borer came in very strong, and as yet we have not seen any of the <u>Agasicles</u> flea beetles in Arkansas.

In a different region in the coal pile this year, the vegetation is down to within five to six inches of the water level. There is an infestation invasion with sedges, nutgrass; a tremendous number of native vegetation species have started to come in.

Another area is Lake Uchubby, where the stem borer also has had quite an effect.

In the Mud Lake region the vegetation is down to the point where algae is competing with it. Much of the material has been decaying for some two or three weeks. There has been absolutely no indication of revegetation by alligatorweed.

In some regions we have noticed vegetation that is literally decimated. We have found some pondweed and some green algae. We found tremendous competition. It seems that we are on the northern fringe of

the range of alligatorweed, and in a weakened condition, it starts going cyanotic, turning yellow, and then natural predators in that area start coming in and taking effect on it. Also, some unnatural predators. We continually find effects in certain places where the nutria have been feeding off these mats.

Bayou Meda is the area that has tended to be the most dramatic. One thing that has really helped us in this part of the river is that soybeans have been planted, as opposed to cotton. Therefore, entirely different herbicide and pesticide sprays are being used, and they are not affecting the stem borer. Downstream from where cotton has been sprayed the stem borer is wiped out. You can literally count the days or weeks since it has been sprayed and gotten into the water system.

In '76, vegetation reached the height of 18 inches in the springtime and about nine inches in the fall. In 1977 it was about 15 to 18 inches in the springtime, and in many places it is down to four or five inches in the fall.

That's it. Thank you.

PANEL DISCUSSION
CORPS OF ENGINEERS DISTRICT OFFICE AQUATIC
PLANT OPERATIONS AND MANAGEMENT

by

John Carroll

As you well know, I am the last speaker on the panel and probably rightfully so, because we have fewer problems than all the other districts appear to have.

A reconnaissance was made in 1975 to determine the magnitude of the problem of aquatic weeds in Oklahoma, with special emphasis on watermilfoil. The reason for this is that Eurasian watermilfoil was already known to be in the state. It was first recorded in a small city lake in southwestern Oklahoma in 1964, and after this it was observed in other lakes nearby.

The first serious case of Eurasian watermilfoil growth was in Fort Cobb Reservoir in southwestern Oklahoma. It got out of control, so an experimental control program was inititated in 1974. The program was continued in 1975. I understand that it wasn't done in '76 and that this problem is apparently cropping up again.

Most of the lakes in Oklahoma that have aquatic weed problems are smaller and relatively shallow, and most are city-owned lakes. Their sole purposes are usually for watersports and recreation. As of yet, no control measures have been undertaken on these lakes, since they are still able to operate the lakes and the impairment is not serious enough at this time to take any action.

One serious problem in Oklahoma is in the Robert S. Kerr Reservoir in the Arkansas River navigation system. Eurasian watermilfoil was first observed there in 1970. The problem is that, since this species can be propagated so easily and rapidly, it can affect the entire McClellan-Kerr navigation system.

Some treatment was done here, but this will be the subject of a talk later on in this conference.

Other than that, there are no serious problems in Oklahoma, and as

far as I know, Tulsa District is not using any control methods except this one experimental project at Robert S. Kerr.

PANEL DISCUSSION
AQUATIC PLANT PROBLEM IDENTIFICATION
AND ASSESSMENT

by

Moderator - J. L. Decell

This panel is "Problem Identification and Assessment." We would like to get everbody more actively involved in some points that we think are pertinent to the topic of problem identification and assessment.

First, we are going to run through two presentations, one by Dr. Benton from Texas A&M on some uses of remote sensing for the identification of problem aquatic plants and how it relates to our project with the people in the Tulsa District. Ed Link from Waterways will present some work he has been doing on the use of remote sensing.

We are then going to talk about the purposes of identification and assessment, why we need information it can provide, and some of the methods that are available. Then we will concentrate on remote sensing, primarily, what capabilities we presently have. We also hope to be able to identify some areas that the research program needs to look at in the future.

We are trying to find out what the real problem is, because as George Bernard Shaw said, "It ain't the things we know that get us in trouble; it's the things we think we know that ain't so!" We are going to try to find out what the problem is really all about.

PANEL DISCUSSION
AQUATIC PLANT PROBLEM IDENTIFICAITON
AND ASSESSMENT

by

Dr. L. E. Link

I am going to talk about remote sensing and a work unit that we have to evalaute how existing remote sensing technology can be used to identify aquatic plant infestations and give some quantitative assessment of what the problems are.

First, we are going to be involved with the electromagnetic spectrum, which is visible energy, infrared energy, and microwave energy. We will be looking primarily at visible, some at microwave, and virtually none in the thermal infrared region. In these regions we have a spectrum of tools that we can use. A lot has been written on this, and some of this may not be new to you. It is probably just a review.

We can remote sense from satellites to the ground in different spectral bands. We can collect imagery up high and look at large areas, or we can get very close to the ground and look in great detail. I am going to start up high and then come down gradually. I will be working on the theme that we have two problems. One is to have a rapid way to survey large areas, to quickly identify potential problem areas. The second is an ability to survey individual reservoirs, or smaller areas, in more detail.

We will start with Landsat, which you are all familiar with. It produces rather cheap imagery because the govenment just about gives it away. It is easily availiable to almost anyone and has repetitive coverage, every six days now that we have two satellites. Shortly we will have Landsat C, which will have even better resolution than what we have now. This system, for those reasons, has the potential for looking at large areas in a hurry. If you look at the imagery, just by simple interpretation you can get a pretty good idea of large-scale problems in a hurry. Realize, though, that the information available is very, very general.

Landsat imagery, as it comes to you from NASA, or from the people

who distribute the imagery for NASA, is not of a whole lot of use. However, when you magnify it you can get some good information. You can see a lot of variations in the lake which are indeed aquatic plant infestations. However, it would be very difficult at this scale and with this resolution to determine what those species are.

We have done some automated interpretation of Landsat imagery. On the imagery the light blue areas are weed infestations, or at least we like to think so, and the dark blue areas are areas without weeds.

In some areas we notice what appears to be scan-line noise. That is because the threshold value we are working with, in order to try to separate water from areas with the submersed plants, is so low that we are actually getting close to the noise level. It is a very difficult thing to separate this automatically by computer processing.

There are accuracy problems involved in this kind of an automated interpretation procedure. You have to be aware of things like this before you believe all the numbers that you might get from this procedure.

Moving a little bit lower now, we are going to discuss U-2 imagery, or high-altitude aerial photography. It is taken with the Air Force spy plane that Gary Powers was flying when he got shot down. It flies very slow, at about a hundred miles an hour. On this imagery you can see submersed hydrilla or egeria in the infestations in the water area.

The Landsat isn't great for looking at sumbersed species because the amplification of the signal in the system is not very high. However, it can identify surface infestations pretty well.

The U-2 imagery gives you the additional capability of being able to look at some subsurface species. You get some water penetration with the color infrared film, and it gives you bigger scale. You get more detail but, of course, it is much more expensive. If you wanted to cover the State of Florida, for instance, you would have a lot of imagery, even at the scale of 1:120,000.

The advantage of U-2 in, say, a regional survey, or looking at a large reservoir complex, is that you can get almost the entire complex on one frame. You can enlarge the imagery and get some detailed

information on the distribution of submersed and surface aquatic plants, but it is not as good, of course, as going lower and getting more detailed imagery. It is a way of looking at large areas in a hurry.

We are doing some work with synthetic aperture side-looking radar. It is a microwave system that transmits energy to the side of the aircraft. If the energy hits water, it reflects off the water surface like a mirror. If it happens to hit a plant infestation on the surface, some of that energy is back-scattered to the aircraft where it is received by another antenna and converted to an image. You then get dark tones for clear water and lighter tones where you have some kind of roughness on the surface.

We have been able to identify some surface aquatic plant infestations with this technique. It offers the advantage of being able to cover 10-mile-wide swaths of terrain in a hurry. The resolution is roughly 15 meters and it is an all-weather imaging capability. It will not give you any information on submersed plants.

I guess the only conclusions I can draw right now are that we can look at large areas rather cheaply in a hurry with Landsat, but we get very general information; with radar, we are not sure yet, we are still looking at that; with high altitude photography, definitely you can get really good information, but it is hard to convince the Air Force to release a U-2 for you to fly your local water reservoir. It may be a problem to get someone with the capability to fly high-altitude photography.

A second class of problems, or "opportunities," is looking at one individual reservoir or area in detail. We have looked at this over the last two years, both within our shop and in conjunction with Dr. Benton at Texas A&M. We have come up with what we consider to be an operational technique that could be used right now by anybody in this room, and we hope we can spread it around.

Essentially we are talking about using low-altitude aerial photography and doing eyeball interpretation of it. The interpretation, however, should be done by someone who is familiar with the problems at

the individual reservoirs or areas at which you are trying to define the problem.

For example, color photography shows some submersed egeria and some surface primrose at Lake Marion. Black and white infrared taken with a special film-filter combination provides more information, with the sumbersed species coming out much better giving us a little bit more information, more contrast. We go to color infrared with a yellow filter, and we find that most of the time this particular film-filter combination gives the maximum amount of information concerning both submersed and surface aquatic plants.

We are recommending that you can go with scales of between 1:10,000 and 1:20,000, flying color infrared photography with a yellow filter, and get very good information on the distribution of aquatic plants in an individual reservoir. Dr. Benton will address that a little more in detail.

We are now in the process of doing some demonstration studies at Lake Marion and Lake Seminole to see just how effective this procedure will be, how much it will cost, and how long it takes us to make the maps to interpret the imagery.

I have some of the maps we produced if anyone wants to look at them. We were able to distinguish waterlily, giant cutgrass, watermilfoil, waterhyacinth, hydrilla, and cattails, all those different species. The imagery mission was flown by the Georgia Air National Guard. It wasn't of the quality that you might expect if it had been flown commercially.

Using someone that has never been to Lake Seminole to interpret the imagery, you would probably be able to distinguish surface and submersed aquatic plants, and maybe take a wild guess at some species differentiation. However, with the help of an employee who had been to Seminole and knew the plant situation there, and with the help of the people at Seminole, we were able to pretty accurately discriminate these species and map their distribution. I think we calculated something like 12 to 14 man-days to cover the entire reservoir.

It seems to be a pretty effective tool for that purpose.

PANEL DISCUSSION
AQUATIC PLANT PROBLEM IDENTIFICATION
AND ASSESSMENT

by

Dr. A. R. Benton, Jr.

We began our research of the Lake Livingston area about three years ago. Where the river makes a rather sharp bend, we found about 1200 acres of waterhyacinth with duckweed on the inside, between the waterhyacinth and the shoreline.

The same day that the satellite overflight took place, we were fortunate enough to get hold of an aircraft and fly the area in color infrared. From the color infrared film we can see a number of things. The mature waterhyacinth appears as a sort of deep, rusty magenta. Where it verges on toward lavender is the immature, flowering stage waterhyacinth. The tan areas are where the Parks and Wildlife people were using 2,4-D BEE.

We came back two years later to see what the dynamics of this particular area were. We came in in July, and at the bend in the river, there was no waterhyacinth at all.

Two months later, in late August, we found waterhyacinth beginning to explode in the general area. Two months after that we came back and found, of course, that it was solid waterhyacinth.

Two different bands of herbicide application can be seen. The green is the more recent, with the sharper, better defined boundaries, and the tan is perhaps a month and a half older than that. Some reinfestation had already begun to occur in the tan areas.

Taking a closer look, we noticed that in the tan areas running through the middle, reinfestation is occurring in the middle of the areas that had been sprayed. This was within two months of the time of the original spraying.

We observed a multimillion dollar development--a golf course and a marina--and took low-altitude shots fairly frequently. Sure enough, they won the prize; they got waterhyacinth, too. They have since acquired a good deal of herbicide and have gotten rid of it temporarily.

We sometimes like to say that we licked that problem, when we are really talking about a very cold winter not letting the stuff come back. We had a very cold winter, and it hasn't really come back in this area yet.

In one instance we alerted somebody to something. We said, "Hey, you had hydrilla here before, but now all of a sudden you have hyacinth." They treated it and turned the whole thing upside down. But they got rid of the waterhyacinth, which was now up to the top. There is a little gap there, but do they have hydrilla! I don't think there is a correlation between treating waterhyacinth and getting hydrilla. The big correlation seems to be the sewage treatment plant. This is in one of those very expensive, very well thought-up Texas condominium areas. They were kind enough to make a sewage treatment plant along with the marina. If you have these two things, where do you put the effluent from the former? You put it into the latter, of course. This makes for a marvelous environment. Not only is it full of nutrients, but the water is quite a bit warmer than the water in the lakes. So you get hydrilla earlier than you normally would have gotten it.

In another area, we used color infrared film to make a discovery. This was the Kickapoo Creek area of Lake Livingston, where a great deal of mixed hydrilla and coontail was detected for the first time. As of this year, there is about four times as much present as was there in early 1976.

Someone was talking about Lake Conroe. Lake Conroe is the place, by the way, where people have gotten together for the purpose of gathering a quarter of a million dollars to spend on something to get rid of their hydrilla. One of the first things they have done, by the way, is to hire the firm called Joyce Environmental Consultants. The first thing that Joyce did, I have been told, was to go out and get some aerial photography.

I would like to close with one very quick message here. The proof and the payoff is, I think, on remote sensing monitoring of aquatic plants, is somebody willing to pay for it? The answer in this case is yes. For two or three years we did "freebies" for the people at Lake Livingston, and this year, 1977, they are paying for flights every

month and a half. They are taking this out of the money they would have put in for actual control and using it for reconnaissance. I think this is a good testimonial.

PANEL DISCUSSION
EURASIAN WATERMILFOIL RESEARCH AND CONTROL

by

Moderator - Dr. D. R. Sanders

We are going to be presenting some information on Eurasian watermilfoil this morning.

I would like to start out by presenting some of the basic biological information on Eurasian watermilfoil. Then Dr. Amundsen from the University of Tennessee will discuss the ecology of the species. Then we'll have some other presentations related to control.

Eurasian watermilfoil, Myriophyllum spicatum, a member of the family Haloragaceae, is a submersed, rooted aquatic macrophyte. It has long, branching, reddish-brown stems with whorls of three to five, usually four, leaves, each of which is finely divided into segments.

The segmentation of the leaves is characteristic in that if there are 12 or more hairs of these segments on the leaves, it's Eurasian watermilfoil. If there are less than 10 hairs, then it's likely to be some other species.

The flowering stalks extend three to five inches above the water surface. There are whorls of pistillate flowers at the base, and there may be perfect flowers in the mid-axis and staminate flowers at the apex. All of these have bracteal leaves that slightly exceed the flowers or the fruit. This is another feature that distinguishes it from a close relative, a native species, Myriophyllum exalbescens.

In North America, Eurasian watermilfoil occurs from southeastern Labrador to Alaska, and south to Florida, Southern Texas, and Southern California. As I said, it's not a native. It's an exotic native to Eurasia and North Africa. We have problems with it both in fresh waters and brackish water. Perhaps the most notable infestation that has ever occurred was in Chesapeake Bay where an estimated 200,000 acres, at one time, were invested with Eurasian watermilfoil.

Concerning the reproduction and the spread of the species, it does produce viable seeds in certain situations. Thirty to forty

percent of these have been demonstrated to be viable under laboratory conditions. As with most aquatics that reproduce by seeds, the field germination rate is considerably lower.

Because viable seeds are produced, there's a strong possibility that the species has been spread from area to area by waterfowl, as the seeds are consumed by the waterfowl and spread and passed through the digestive tract.

However, once the species reaches an area, the most notable means of reproduction within a water body is by fragmentation. When the stems are broken, they may travel with the current and eventually settle to the hydrosoil surface. Here they become lodged in some sort of structure, send down roots, and become anchored in the hydrosoil. Only a few nodes are necessary in order to establish a new plant. The fragments can remain viable out of water for several days if sheltered from the sun, such as beneath boats or boat trailers.

Eurasion watermilfoil can reach a very high density, high biomass, in many types of situations.

Concerning the benefits and the detriments of Eurasian watermilfoil, it would be a misconception to say that there are no benefits under certain situations. There can be some benefits from Eurasian watermilfoil. It may serve as protection for small fish and other fish foods. It may relieve nutrients from the water column and hydrosoil. It may contribute to the control of erosion along the shoreline in certain situations. And it is used somewhat by waterfowl as food, although there is some controversy about the extent to which it is used.

From a detrimental viewpoint, it may cause stunted and imbalanced fish populations when it occurs in large populations. By affording too much protection, the larger fish are unable to prey on the smaller sized classes. The carrying capacity may be reduced due to nutrient removal.

Obviously, other detrimental effects are curtailed recreational activities, restricted navigation, reduced flood control and irrigation capability, increased public health threat due to the associated build-up of the mosquito population, economic depression due to lost tourist income--I'll have some comments to make about that in terms of the

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impact in Canada--depressed land values, and decreased quality of potable water.

These are some, although I wouldn't guess that these are all of the detrimental factors. My experiences have been such that I'd have to say the potential detrimental factors far outweigh the beneficial aspects of this species. In many cases we would have to consider it a true aquatic weed.

We were funded by Union Carbide, for the initial part of the watermilfoil study, as part of a research program they had concerning the cooling of steam plants. The milfoil follows the steam plants in many of these locations.

When we got into the study of milfoil, we found that a good deal of the previous work had been directed primarily to its control, to the morphological response of the plant to various control measures, and to the problems arising from various control measures.

Up through 1969, TVA (Tennessee Valley Authority) spent $1.7 million on control of this species. As far as we could tell, outside of some personal interest on the part of people who were involved with it, no ecological research has been done in the southeast. Some studies have been done--a little one by Patton up in New Jersey earlier, but it's more taxonomic and flouristic in relation. By that I mean it addressed what the plant was and where it grew, but did not address very closely the relationships of the milfoil with the other organisms in the aquatic ecosystem.

There are several problems with this. Dr. Sanders has spoken of some of them. One of them was discovered by one of my research associates who studied milfoil in Kashmir, in India, in England, and in Czechoslovakia, and also in North America.

There is a possibility that one of the problems we see with the milfoil and with its control is that we are dealing with a complex of evolutionary divergent subspecies or varieties, or whatever you want to call them. Frankly, it is our contention, and this may last no longer than noon today, that the species we are dealing with here is a species of convenience. We are naming it something because we think it looks

enough alike across the southeast up to Ontario, etc.

There is a possibility, which requires some in-house biochemical studies, that we are looking at subspecies both with exalbescens, which is a "native" of North America, and spicatum, which is not "native." These may be highly variable subspecies or varieties of Myriophyllum verticillatum, which is very widespread and very erratic species, distributed circumboreally. I am not familiar with the distribution of any of these three species, if we can call them that, in the southern hemisphere.

I have indicated in diagram form that in Block 1 are macrophytes. In this instance we are primarily concerned with Myriophyllum spicatum, although I think with many aquatic plants, macrophyte just means big plants. We are talking about plants with a vascular system, as opposed to the algae.

You can substitute anything else for watermilfoil. You can substitute hydrilla or Potamogeton or elodea, or anything else that grows entirely submersed, and put that in the macrophyte box.

For those of you who aren't familiar with such box and arrow diagrams, from the biological point of view, the arrows indicate exchanges. They do not imply rates or amounts. We don't have much of that information. The boxes imply separate compartments.

As with anything else in the "real world," it's pretty hard to draw a firm line around something and say everything is either on the left or the right of that line. So these are matters of convenience. We construct them more to make sure we're not leaving obvious things out than for any other reason.

Our tasks then is to measure the rates of transfer between these compartments--that is, how broad the arrows are, how long they should be, and the relative size of the compartments. The size of those boxes does not imply the relative importance of the various compartments.

As for the situation that we think is operating with plants like watermilfoil, we don't think they're living alone. That sounds a little trite, but they are covered with epiphytes, diatoms, which are algae, and many other algae without calcareous outer coverings, so much so that

the weight of a collection of milfoil, the fresh weight, sometimes is 75 percent epiphytic, attached, organisms. It is very difficult to wash off these other organisms.

Those of you that have taken a plant that's growing underwater won't be surprised by the fact that they are covered with things. But the fact is that an interesting thing is going on here, we think. We're in the process of exploring it now.

Watermilfoil will grow, particularly, in water in which we cannot measure carbon dioxide, which is a carbon source for photosynthesis. Yet we think a significant amount--and some research has shown this, too--a significant amount of its carbon comes from bicarbonates deposited by the epiphytes living on the milfoil. In periods when CO_2 is available--and this is temperature related, seasonal related, how much the flow is, etc.--it does well. It looks like that's why it does so well in water where nothing else seems to--because it has this capability of taking up carbon.

We're trying now to get an approximation of the exchange rate between diatoms in particular. We found and identified some 30 species commonly associated with watermilfoil, that is, some of them actually attached into it, and studied the exchange of carbon between the diatoms and watermilfoil.

The possibility exists, although we're having a little difficulty measuring it right now, that there is an exchange in the opposite direction. That is, the milfoil, besides providing a physical substrate for these epiphytes, may be providing some necessary metabolites. We think that the nature of the interchange is poorly understood. Before some of you start wondering why on earth we care, it just may be that as an applied thing, upsetting the diatoms would upset the milfoil without making the lake, or the river or whatever, subject to a harsh chemical treatment.

I remember that years ago it was not too difficult to control algae in a pond. I didn't say eliminate it, I said control. If, in fact, we can control some of the algae, upset the interchanges--in other words, break some of the arrows between the macrophytes and the

epiphytes--we may make some gains. We're looking at that.

In addition, one of my colleagues, a microbiologist, is now investigating the relationship between the macrophytes and the bacteria and fungi associated with them. The bacteria and fungi are not only decomposers of the organic material in the system, but also act epiphytically. Some of these bacteria are photosynthetic, producing excess metabolites which are released into the water--organic compounds released into the water.

We have dry weights, including epiphytes, of about 800 grams per square meter of substrate. We don't have any cubic meter estimations. We never could figure out quite how to do that. We just clip everything from the bottom and weigh it in square meter plots. That rate is pretty high. It compares favorably with the amounts of dry weight of sorghum grown in a fertilized field in Knox County, Tennessee.

So, we're looking at epiphytes, both bacterial and algal, primarily, and the exchange between those and the macrophytes. We're looking at decomposition rates of macrophytes. Those of you who have seen milfoil, where it's been mechanically controlled and allowed to sink to the bottom and so forth, are aware of the kind of problem that creates--the eutrophication, the odor, the discoloration of the water, the screams of the tourists, the screams of the people who run the steam plants, and whatever.

We're trying to find out how rapidly and how intimately these turnovers are related to the growth of the macrophytes. We know that there are animals that eat milfoil. I won't get into some of the controversial ones. But there are other organisms that eat it.

We have just eyeball, not scientific, observations on one stand that we know flowers every year and sets a good amount of seed. We really don't know why that one stand does so well. We're trying to find out. And it attracts tremendous numbers of ducks in the fall. I am not a bird behaviorists, but there may be other reasons the ducks are there. They come repeatedly to this one place and graze on it to quite a large degree during this good seed-set time. As has been mentioned,

the amount of that is probably negligible when we talk about the size of the problem.

We ought to investigate whatever else might eat it. We really don't know, or I am not aware, of anything saying that certain native species live in it, eat it, need the chemical changes that are created by its presence to further their egg production, or whatever. Those things, so far as I know, have not been investigated. Those, of course, are peripheral to our immediate concern, but are things that we have to keep in mind.

As to the nature of the bottom, about the only place we have found that it doesn't grow, in terms of the strict nature of the substrates, is on solid rock. It may be that we just haven't found enough solid rock yet. It may well grow there, too, in the crevices, just as fruit trees grow in the crevices of cliffs by the rivers around here.

A great number of treatments, chemical and mechanical, have been applied to milfoil. I'm not an expert on treatment, but whatever treatment is applied to the macrophytes for elimination will affect all other components of this system.

In other words, when you treat the macrophyte with chemical treatments and change its chemistry, you also change its relationship with the epiphytes and decomposers. Once that happens, we don't know what else is going to happen. A treatment that eliminates the pest weed may increase the epiphytes or give similar plants, continued algaed blooms, for example. Or it may eliminate all related life forms and therefore upset the balance of fisheries, etc. These things have not really been looked at in a comprehensive fashion. No one study, of course, or one group, can do all these things.

In looking at the relationships between macrophytes and epiphytes, between decomposers and macrophytes, we're hoping to find the label or transfer of certain organic compounds, certain metabolizers, that we can demonstrate are essential to the growth and high productivity of the milfoil.

We have some environmental measurements on where milfoil grows, but they are inconclusive. As I said, one of my people is not sure of

the integrity of it as a species, but the thing we all agree on calling watermilfoil at least in this region, Myriophyllum spicatum, has a wide ecological amplitude. It likes hot water and it likes cold water. We find it in the TVA lakes that are the coldest. And I'm talking about growing in 50 to 55 degrees Fahrenheit in the summer time. These are lakes where the water supplying them is released from upstream dams, underneath the dam, coming up quite cold.

Other lakes, like Loudoun, near Knoxville, where it's recently been found, are pretty warm all summer long. So, milfoil doesn't mind warm water.

Around the steam plant where we first began our studies, it grows well at the intake and it grows well at the discharge.

It happened that the steam plant at which we were studying was scheduled for a series of intermittent repairs, which meant that they had alternate periods of hot water discharges with cold water flushes. In these fluctuating temperatures the biomass productivity dropped five-fold. It didn't kill the milfoil but it limited the growth.

That may not be a very practical solution for a 100-mile-long reservoir, but it's a possibility that should be explored a little bit further when we're talking about controlling it around an intake, or around a boat dock or something, where we're already discharging heated water.

In terms of light, it grows at depths at which we cannot measure light. We find it to eight or nine feet in TVA reservoirs which generally are turbid. It's reported to grow at 40 feet in some Ontario lakes. It seems to have a very low compensation point, that is the point where induced photosynthesis has to equal respiration.

It likes basic pH's, but in the Oakridge National Laboratory tanks, which were spring-fed from a deep spring, the pH's were as low as 4.8, and it did fine. In fact, after a while we found that it was a good way to grow it because the calcareous epiphytes don't like that low, or acid, a pH. There is an indication that the milfoil modifies the pH in dense stands, making it more basic.

There is one other reason, I think, to study it, although the wet

weight and the dry weight of milfoil are quite different. There's a lot of water in that plant, a lot of very large cells without much cellulose. It has some value for forage.

The National Academy of Sciences put out a bulletin just last spring promoting the use of aquatic weeds as a food source for underdeveloped nations. Perhaps some of you here participated in the compiling of that booklet.

Watermilfoil--*Myriophyllum spicatum*, again, if that's a "good" species--grows around the world. Many suggestions have been made as to how to harvest it, how to dry it, how to use it for livestock food, etc. It is, in places, eaten as a salad. It doesn't taste bad. It's about like eating watercress. If you put a little salt on it, it tastes like you're eating a salty sponge. There's not much more to it than that, but it does have some nutritive value.

As Dr. Sanders mentioned, in certain situations it may be used to improve the quality of the water, by acting as a sink for excess nutrients which are discharged into the water for other reasons. That possibility should be investigated.

Its productivity is high, and I leave you with one thing. This is a little bit farfetched, but with a plant like this growing in our water systems, where it is not a threat to navigation, recreation, etc., it is producing a potential energy source in a situation where nothing was before.

There is one unusual thing about this, as opposed to the introduction of other species. You're familiar with how kudzu and other plants that have been introduced take over and out-compete native vegetation. You're familiar with animals that have been introduced and take over and out-compete native fauna.

This plant, in the Tennessee Valley system, at least, is not out-competing anything else because there wasn't much else there, not in these dense stands. There just aren't extensive aquatic macrophyte stands. If there's an ecologist here, he'll shoot me, but this plant occupied an empty niche. It occupied a habitat that wasn't being utilized by macrophytes.

This may be one of the very few introduced species that biologically has functioned in that fashion. It may be that if cattle feed and that sort of thing really becomes scarce, we will one day be harvesting this plant or others similar to it. If not here, at least in other parts of the world perhaps more tropical, where the terrestrial soils are less fertile. It might be harvested and used as fodder.

You may think of that, those of you who are responsible for controlling it, when you're out there getting 2,4-D all over your face and that sort of thing, trying to explain to some irate dock owner why he can't get his boats through it to the dock.

PANEL DISCUSSION
EURASIAN WATERMILFOIL RESEARCH AND CONTROL

by

A. Leon Bates

Our program is considered an aquatic plant management program in the sense that we, in some cases, are interested not only in the control of certain noxious species but also in the promotion of some desirable species. We'll look at the control program in that context as we go through.

To give you a brief introduction to the Tennessee Valley, it's a rather large watershed system. It's about 41,000 square miles, the fourth largest river system in the U. S. We have about 11,000 miles of reservoir shoreline and a series of impoundments along the Tennessee River. We have about 650 miles of navigable channel. These navigation facilities are, incidentally, managed by the Corps of Engineers.

As far as TVA facilities, we have 33 reservoirs, nine of these on the mainstream and 24 on the tributary streams of the Tennessee. We have several possible fuel generation plants, of course, with one operational nuclear plant and six under construction.

As a brief background on the history of the aquatic weed problems in the Tennessee Valley we find, as most of you find, that it is very necessary to arrive at a definition of which plants are beneficial and which are harmful. In that sense, we categorize the beneficial plants as aquatic plants and the detrimental plants as weeds.

TVA began some of their weed control efforts back in '33, primarily as a spinoff of the effort to combat malaria. Malaria, of course, was spread by the Anopheles mosquito, which was directly tied to aquatic plant vegetation along the shoreline.

The culprit was Eurasian watermilfoil. As Dr. Amundsen mentioned, there is a little bit of taxonomic confusion about this plant. As far as we know and can find out, at the present stage, we do have the spicatum. This is an area, I think, that requires more investigation.

This past year Fort Ladner Reservoir became infested and, in fact,

it's infested upstream to the extent that it's becoming established in a riverine-type habitat. This is the first occasion where it's in a river-type system.

Depths vary considerably. On the upper reservoirs with higher turbidity, depth of a growth may be eight or nine feet, as mentioned. In some of the other reservoirs, it's certainly not uncommon for it to extend down to 12 feet or more.

To give you the background of Eurasian watermilfoil in the Tennessee Valley, this species was introduced about 1953 by an individual who had the misconception, perhaps, that he would promote the ecology, and particularly his fishing business, in the particular area of Watts Bar Reservoir.

The unfortunate thing about it was that it wasn't discovered and positively identified until about 1960. This would be a very critical factor, as most of you people know. I think this is probably a case in point, that the early surveillance and detection is one of the most cost-effective things that you can do.

In 1961 the plant had moved about 40 miles downstream, as far as we know, by downstream transport of fragments. In '62 it was 270 miles and then by 1963 it had been well established in all the 270-mile stretch. In '65 we noted an upstream movement into the Melton Hill Reservoir. Then in 1968-69 we had a peak infestation of about 25,000 acres.

From the recent peak infestation a few years ago--to give you an idea of some of the total acreage of milfoil in the TVS system--since 1974 we had about 11,000 acres. It went back up in '75, due, in part at least, to our reduced control effort. In 1976 it reduced to about 8000 acres.

Certainly one of the aspects you must look at in the control of this species is the life cycle of the plant. This plant propagates by fragmentation in an asexual means, and also produces viable seed, in most cases in abundance. We have only a very rare situation where we have plants of seeding origin, as far as we know. We find viable seed in sediments up to two years after seed-set, up to densities of

perhaps 2000 to 3000 per square meter.

Interestingly enough, we dry-store Eurasian watermilfoil in little vials, and we've had five-year seed to germinate very easily--a high germination percentage.

The asexual fragmentation, of course, is a very efficient mechanism of spread. This is primarily by abscission fragmentation that occurs naturally. Also, mechanical fragmentation occurs by various means.

We have noted two bimodal peaks of abscission production, one in early spring and one in the late growing season about this time of year.

Viable seedings of seed origin are very rare, as far as we can determine, and the flowering is very variable, even within reservoirs, and of course from year to year.

Of the significant dispersal mechanisms, as far as we can determine, the obvious one is that the normal stream flow transports fragments downstream. We have found that wind action can disperse fragments upstream by moving against the current. Of course, the fragments, especially when they are floating on the top few centimeters of the water, are very subject to this wind-induced movement. We have had movement upstream through a series of culverts that you wouldn't expect. Boating, of course, is a very obvious one--on boat trailers and live wells, etc.

We have done a limited amount of work with waterfowl transport. We have looked at some gizzards of various species of waterfowl. We do not yet have a sufficient number to indicate positively that any particular seed are transported, but we do know that certain species, like coot, do ingest quite sizeable quantities of Eurasian watermilfoil. We have found a few seed, but we haven't been able to get the seed to germinate. We do know that fragments can be spread by adhering to the plumage of the bird and, of course, transported by asexual means.

To get into the control aspects of TVA's Eurasian watermilfoil program, the control strategy is to have a maintenance control program. Eradication certainly is not feasible at anything less than 99.9 percent. It's probably even higher than that because it essentially takes only

one small fragment. Chemical control is, of course, to reduce the excessive infestations on a maintenance program's strategy.

The potential habitat in the Tennessee Valley, however, remains quite great. We still have about 100,000 acres of water less than ten feet deep. A large portion of this area is suitable habitat for the migration of Eurasian watermilfoil.

I think that on the basis of what we know up to this point, there are very few water systems in the continental U. S., at least, that are safe or immune from infestation of this species. I think certainly the people in the irrigation systems of the west can be a little bit apprehensive because I think it will grow there.

As I mentioned, we reduce excessive infestations for maximum utilization. Of course, this depends upon the user group. At the same time we try to minimize the ecological effects, while insuring that the waters are safe for human use and that there are no catastrophic losses in aquatic inhabitants.

In most cases the areas to be treated are those that would have the most potential for contact recreation and also would have the greatest economic repercussions if they were not maintained.

For example, one reservoir alone, the Guntersville Reservoir in northern Alabama, has about $59 million worth of recreational investment in facilities. Over 800 people live on this lake year-round and about another thousand families have seasonal homes here. On this one reservoir we have about six and a half million recreational visits per year. So you can see the economic repercussions of not trying to maintain control on a reservoir of this type.

The optimum treatment in the Tennessee Valley is now about 7000 to 8000 acres. We feel that if we can treat in the neighborhood of this acreage we can certainly continue our maintenance program. This is roughly equivalent to 10 percent or less of the surface cover of the lakes.

There were some questions yesterday directed to scale and resolution and ability to detect individual colonies. We find that in some of these multi-spec photos we can distinguish things like Chlorox

bottles floating on the surface and individual stumps. Particularly if you have a large number of individual colonies of Eurasian watermilfoil, you can spot the individual clumps of plants with multiple stems.

Mr. Goldsby will discuss water level management with you in just a few minutes. This is really our most effective management tool. As mentioned previously, we didn't really have significant weed problems until Eurasian watermilfoil. I think some of this was due in part to the water level management scheme of the Tennessee River system.

Two formulations are available for our use, the dimethylamine (DMA) salt of 2,4-D, which is a liquid formulation, and the butoxyethanol ester of 2,4-D, or the granular formulation. We have used exclusively the DMA salt for the last two or three years because of the economy of the liquid.

Our EPA label indicates that we have an application rate of 20 to 40 pounds. This, of course, is actually about 5 to 40, depending upon the water depth. In most cases, if we have to consider the 40-pound acid equivalent per acre, it's an area that we wouldn't normally treat because we wouldn't get the maximum benefit. Target concentration is about two parts per million at the time of treatment.

We have used two methods for application. In the years passed we've used helicopter application for both the granular and liquid formulations. It's a very effective, efficient, and economical tool if you have large areas of treatment. On the other hand, we use outboard boats now and have also equipped an airboat for shallow water infestations. We treat by subsurface injection, undiluted herbicide.

There are some herbicide use provisions that we must comply with, and, of course, the Corps of Engineers and others must comply with also.

The product must be registered by EPA for its intended use. TVA has tolerances for 2,4-D as one-tenth part per million in potable water and one part per million in or on food commodity fish.

Irrigation is not practiced in the Tennessee Valley so we do not have to contend with this portion of the registration process. There is an effort underway, incidentally, to expand some of these labels to include other federal agencies using some of the data that TVA, and the

Corps, and various other federal agencies have generated.

2,4-D is really quiet selective and effective for control of watermilfoil. Other species, in general, are not affected. One of the repercussions of treatment with 2,4-D, however, is that the vacated niche is often occupied by other invader species. Some of these species include the spiny-leaf naiad, Najas minor, American pondweed, American elodea, Brazilian elodea, and the other pond weeds. I commented to a group in Minneapolis that we call these the "niche snitchers."

This is one of the questions that's been looked at from the study at Conway with the white amur. Is the white amur a "niche snitcher?"

One of the post-treatment effects is habitat destruction for certain organisms, particularly those epiphytic ones that were mentioned. There are nutrient releases in the fact that the plant in a way acts as a nutrient pump. It can release nutrients in the decomposition process. The species replacement problem is one of the factors that result from the treatment with 2,4-D.

In some isolated embayments of the Tennessee River, we find that these nutrient releases are probably stimulating some algae growth. This is the blue-green algae anabaena, or alenbeia, in this particular case.

We use aerial imagery to assess some of these major community changes. We use this also in our side assessment work, in relation to our siding process for TVA facilities.

In connection with our operational program we also use aerial photography. These annual overflights are in October. This is the period of year when we have, in general, the maximum biomass and at the same time we have the greatest number of cloud-free days. It's a good time for photography. We use, on the operational scale at least, a 1:600 foot scale on panchromatic film. It's very satisfactory. We're able to distinguish, certainly, the target species, with some pattern recognition. The trained interpreters were able to distinguish, in most cases, other species.

This imagery is used the following year to plan our control program, because if it's there in October, then in almost all cases it

will also be there the following spring.

I think it's significant to relate to you that since we have been treating the milfoil, for over 15 years, that from the control angle, we have not had any taste and odor problems in potable water attributable to the treatment of the watermilfoil. We have had no fish kills attributed to the treatment. And on the management program, we have had no major extension of infestation.

Our biological monitoring has shown no demonstrable long-term effects. These are very hard to quantify. As you know, we have a tremendous within-reservoir variation. We also have a tremendous between-reservoir variation. It's very difficult to get a good handle on the natural successional dynamics of some of the aquatic organisms, but we do have some programs going on that indicate that there's been no major long-term effects on the phytoplankton and zooplankton, macroinvertebrates, and fish. Some of these need more thorough study, of course.

We treated 7700 acres in '74. We have treated about that much in 1977, and in 1978 we project about 6000 acres. This, I think, indicates to you that we are more or less on a maintenance program.

Some of the research needs were identified at the Agricultural Research Service in California a couple of weeks ago. Some of those are very important, I think, if we are really going to get a good handle on how to manage the species.

The abscission fragmentation is certainly a productive area of research because it is such an efficient means of reproducing the plant. If we can reduce the efficiency of the plant spreading, I think we have a better handle on management.

Some of the other ecological studies of the species need to be conducted. We simply do not know its effect on fisheries, for example, the epiphythetic communities, the benthic communities, and there's also certainly a lot of room for synergistic relationships with aquatic herbicides of various sorts.

We now consider Eurasian watermilfoil to be an inextricable, exotic introduction. We feel that it's a species that we're going to have to live with and we think we're going to be in the same boat with a lot

of you folks in the years to come. I think with concerted effort, though, it's not an insurmountable task. Thanks.

PANEL DISCUSSION
EURASIAN WATERMILFOIL RESEARCH AND CONTROL

by

Terry Goldsby

In the short time I've been with TVA, one of my responsibilities has been to study water level fluctuation as a control tool. It is a most effective control tool.

One of today's primary methods of weed control is the use of 2,4-D herbicide. However, during the last few years, rising chemical treatment costs have made us seek ways to reduce our herbicide usage. One of the best methods of accomplishing this reduction is going to be a more effective use of water level fluctuation.

The TVA mainstream reservoirs are fluctuated to correspond to weather patterns in order to achieve the best flood production and the most efficient use of the water. They have a low in the wintertime, extremely low, to accommodate the spring rains. Then they are brought up with the spring rains to about what's called normal summer pool level. They are lowered again in the fall to begin getting ready for the spring rains again.

This is the best system on the mainstream reservoirs for flood control, plant control, recreation, navigation, and power generation.

This scheme not only exposes a maximum amount of milfoil habitat during the cold months, but it also breaks up the constant pool at other optimum growing periods during the year. The constant pool, of course, is most conducive to plant growth. We have a tremendous draw-down on some of the tributary reservoirs.

The operation pattern on the mainstream lakes gives us a zone of effective control from the normal summer pool level down to about one foot below minimum winter pool level. This one foot below the minimum winter pool level is called the zone of erosion. The forces acting on the plants there are wave action, siltation, etc. The spring surcharge also gives us some measure of control with which to prevent some reproduction.

From the experience of working with these fluctuating lake patterns, TVA has found that water level management is the most effective control as related to persistence. It increases the plant mortality, from drying and light reduction. It's very economical, but of course, it's limited by other program interests.

One of our best experiences with the use of water fluctuation has been on the Melton Hill Reservoir in eastern Tennessee. Melton Hill is a Tennessee Valley Authority multi-purpose impoundment of the Clinch River, which is a major tributary of the Tennessee. The dam is south of Oak Ridge, Tennessee, and impounds a 44-mile-long reach of the Clinch. It's equipped with hydroelectric generating units in a single navigation lock that permits river traffic to reach Clinton, Tennessee.

The normal water level fluctuation pattern consists of a draw-down of two to three feet over a period of a few days. This takes place at irregular intervals depending on the need for power generation.

The usual pool of Melton Hill is about 794 feet above mean sea level and at full pool level, normally which is about 795 feet above mean sea level, the water surface is about 5600 acres.

The exotic aquatic angiosperm, Myriophyllum spicatum, was discovered growing in Melton Hill in late 1965. The area of infestation at that time was less than 25 acres. A special draw-down to 785 was conducted on Melton Hill to expose the milfoil plants within practically all the infested area during January and February of 1966.

The low water level greatly reduced the seriousness of the problem, but some plants survived. With seeds in heavily silted areas, it subsequently recovered to more than its former abundance, and in '71 it was spread over an estimated 1200 acres.

A program of extremely low water levels, such as the one in '65, was difficult to repeat because of the conflicts and demands of the various water uses, such as for power generation, navigation, and water supplies. The alternatives that were considered were partial dewatering for a long period of time, more complete dewatering for short periods of time, and of course, treatment with the herbicides.

Because of the need for control and the limitations on long-term

deep draw-downs, several management techniques have been employed. The techniques which have been used include two different water level manipulation schedules, herbicidal treatments, and an integration of these.

During the winter of '71 and '72 an attempt was made to hold the water of Melton Hill within the defined upper and lower limits. An upper limit of 791.5 feet above mean sea level was defined from December to mid-February to increase the probability of emersion of Eurasian watermilfoil and its death by exposure.

A lower limit of 793 was defined from mid-February through April to decrease the probability of vegetative regrowth and the growth of established colonies. Other upper and lower limits, consistent with these general principles and with expected operating needs, were defined. The upper limit at 791.5 was frequently exceeded because of the need for electricity generation. Other limits, however, were observed to be satisfactory.

During the following two seasons the water level fluctuation returned to the normal pattern. During the next year all observed colonies of Eurasian watermilfoil were treated with 2,4-D between May 21 and June 21, '73. A total of 1402 acres were treated with about 40,000 pounds acid equivalent.

During the 1974 growing season 2,4-D was also used to hold the milfoil in check. During that period a total of 609 acres were treated with about 25,000 pounds of acid equivalent. Both the DMA liquid and BEE granules were used.

Herbicide was again used to maintain control over the milfoil during the '75 and '76 growing seasons, with 314 and 350 acres being treated, respectively. During those two years a total of about 26,000 pounds of 2,4-D, as both formulations, was used.

During this period we integrated a new water level fluctuation schedule. This schedule lowered the water surface to approximately 791 feet above mean sea level twice a month, from September '75 through March '76, and again from August '76 through March '77. The duration of these draw-downs was very short, usually lasting only two or three days. We made milfoil acreage determinations each fall during the study period

and after control efforts of the previous growing season were completed.

The water level was consistently lower during '71 and '72 than during any other study year, as shown by the mean levels. Tabulation of the lowest contour elevations reached shows that '72 was one of the lowest years. That was when we had one of the special water level fluctuations. The estimated acreage colonized was lower in '72 than in '71, attributable probably to the draw-down.

About five months after the extensive application of 2,4-D herbicide, the estimates for 1973 showed a 68 percent reduction in total area compared with '72. Again, '72 was the year when we applied limited herbicide but we did use the water level fluctuation. This decline in watermilfoil infestation was over 80 percent in '71, the year we didn't use any water level fluctuation.

In 1974 the acreage of Eurasian watermilfoil remained about the same as that for the previous year, despite the reduction of the quanity of 2,4-D applied. This shows that Eurasian milfoil colonies can be maintained at a low level infestation by use of less herbicide than is needed to reduce them from the high level to a low level.

After the '75 growing season, another year without special water level controls, watermilfoil acreage doubled that of the previous years. It went from 153 to about 330 acres. This was primarily due to a 50 percent reduction, from '74 to '75, in the acid equivalent of 2,4-D applied. This reduction was due to some questions raised about residues and toxicity the concerned public. We proceeded to answer these questions before continuous full-scale treatment.

During '76 the watermilfoil infestations were again reduced to approximately the low acreage figures which were estimated in '74, although the quantity of 2,4-D applied remained about the same as in '75.

It was expected that the semi-monthly draw-downs used in '75 and '76 were going to give similar results during this past year, '76-'77, although we haven't completed evaluating the data.

In March of '77 we conducted a survey to determine the effects of the unusually severe winter, combined with the semi-monthly draw-down, on watermilfoil root crown viability.

No root crowns were found above the 791.5 mark and all of the root crowns below 791.5 were viable. Therefore, it's felt that the combined effects of herbiciding and semi-monthly winter draw-downs have eliminated watermilfoil above 791.5 feet in Melton Hill, while the harsh winter of '76 and '77 did very little to reduce the deeper infestations.

Most hydrosoil in which the root crowns were found was not dewatered during the coldest temperatures.

The result of controlling the water level fluctuation for the Melton Hill Reservoir during the winter of '71-'72 indicated that Eurasian watermilfoil was completely eliminated at contours that were dewatered for three consecutive weeks or longer.

Significant reduction had also occurred at elevations that were dewatered for shorter periods of time. Partial reduction occurred at elevations that were continually inundated. Similar results were produced by semi-monthly draw-downs during the winters of '75-'76 and '76-'77, without having to hold the water level within defined limits for prolonged periods of time.

Herbicidal treatment of colonies throughout the entire reservoir has been effective in reducing the total infestation of milfoil. However, surviving colonies remain throughout the reservoir, and infestation is rapid unless annual treatments with herbicide and these special low water levels are used to maintain a satisfactory level of control.

Our main philosophy at this point is that every reservoir should be evaluated and a weed control program designed especially for it. We have so many different types of reservoirs that this is particularly pertinent in our situation. Throughout the Corps there are different types of reservoirs, too.

A combination of maintenance; herbicides; and high-frequency, low-amplitude, short duration winter draw-downs seems to hold the best promise for the control of Melton Hill and should aid in the prevention of infestations such as Guntersville Reservoir, where we can achieve only about a three-foot draw-down, a very limited water level fluctuation capability. Thank you.

PANEL DISCUSSION
EURASIAN WATERMILFOIL RESEARCH AND CONTROL

by

Loren M. Mason

I find it very interesting in hearing the paper that was just presented that, despite the geographical and climatic conditions of various parts of the country, we still find a lot of similarities with the problems of Eurasian watermilfoil.

This is really our first year in implementing a control plan, our's is strictly an O&M Corps control plan, and I think we're going to find that many of the things that have been presented this morning are probably going to be true in our case.

There's an old saying, something like, "An ounce of prevention is worth a pound of cure." I believe this is as appropriate as it's ever been, particularly when we are addressing the presence of a known aquatic species, which may at first appear to be insignificant, but which ultimately has the potential of developing into a major economic problem.

Such I believe is our responsibility, recognizing the pending aquatic plant infestation problems within each of our respective boundaries and then taking appropriate actions to control such infestations.

My presentation today, I hope, will illustrate the cooperative effort that has been exercised between the Waterways Experiment Station and the Tulsa District Corps of Engineers in addressing such a problem.

The Tulsa District encompasses all of the State of Oklahoma, portions of Kansas, Mexico, Colorado, Texas, a little bit of Missouri, and portions or Arkansas. Of all these areas there are two major river drainage areas within the District, the Arkansas River and the Red River. Our basic aquatic plant problem lies within the State of Oklahoma.

We had a reconnaissance survey made in 1975 of all the waterways within the Tulsa District. We found 23 major sources of aquatic plant infestations. However, only 12 of the 23 contain Eurasian watermilfoil.

At that time we had a total figure of 8206 acres of infestation.

As far as I know, only one of the 12 has ever had any treatment, and this was specifically at Fort Cobb Lake. So, at this time I think I'd be safe in saying that we probably have at least the 8206 acres or more.

New sources have been found within the State of Oklahoma within the past six months, which included several private farm ponds. I saw five or six impoundments at Fort Sill about two weeks ago that are loaded with Eurasian watermilfoil, which I'm not sure was included in our original survey.

We have additional district flood control projects that we found in the last two weeks. At W. D. Mayo, which is closer to the Arkansas border and below Robert S. Kerr, we found new infestations. Also, in Weber's Falls, which is above Robert S. Kerr, we found additional infestations. So the question that I'm asking myself is, do these infestations warrant a cooperative control effort with the State of Oklahoma? I seriously think they do, and for us not to approach this subject with the care that it needs, I think, is only leading ourselves into problems in the future.

The overall aquatic plant problem on the Arkansas navigation system has been minor until the last couple of years. Until approximately 1971, infestations of any noxious aquatic plants were unknown. In 1971, however, Eurasian watermilfoil was first discovered and to date has progressively increased in size and overall acreage.

Last year I presented the problems that we saw and the need for a control plan. From that, this cooperative effort was established between WES and ourselves, in which we address the problem head-on.

In 1976, we determined the infestation to approximately 600 acres. Since then we've revised those figures and we're talking, we're sure now, in terms of about 1000 to 1200 acres.

As a result of a more recent survey made within the last 30 days, we're convinced that we have more, although we don't have a total acreage figure yet. We're hoping that with the aerial infrared photography Dr. Benton has flown for us within the last three months or so, we'll have a good hand-hold on what we've got.

Probably our biggest area of infestation is on Robert S. Kerr

Lake. This also happens to be located within an area which is under cooperative agreement with the U. S. Fish and Wildlife Service. We've had some problems in convincing the U. S. Fish and Wildlife Service that they should allow us to control milfoil in this area. We feel that the key to our maintenance program is being able to treat this area to prevent sprigging. We felt that this was going to be a natural area that would keep causing us problems.

There's a heavy algaebloom lying on top of this milfoil. I was very interested in comments made this morning concerning the algaebloom. I don't know that this is unusual, but it's the first time I've ever noticed it in the lake. When we flew over it about two weeks ago it was laden with algae. I've never seen so much algae in the lake in the time that I've been surveying it. Whether this is an indication of things to come or not, I don't know, but I thought it was significant.

Another area of milfoil infestation is within the Illinois River, which is a tributary to the Arkansas River. It is a put-and-take trout stream, which is maintained and operated by the Oklahoma Department of Wildlife Conservation. The Oklahoma Department of Wildlife Conservation had expressed a real concern in our exercising a treatment program within the trout stream. Thus far we've been unable to convince them that our activities will have little or no effect on their program. It is a very pristine area. The water quality is very high and the Eurasian grows in this area like crazy. It's just phenomenal how it closes it in.

Many secondary impoundments, and oxbows and slews, that lie off the navigation system are prime breeding areas for Eurasian watermilfoil and other aquatics. These are connected to the navigation system and have the ready access for flowing into the river.

As I said, this is our first year in exercising any type of control. We are experimenting with different types of equipment and with different types of safety techniques for workers.

We chose the helmet and goggles, and the respirator. The helmet it primarily to cut down the noise generated by the boat, as well as to protect the workers, since we will be treating in heavily wooded areas.

We chose the mask because we are using 2,4-D pellets and we found a tremendous amount of dust coming off the cyclone spreader. In some cases, the pellets were even being put back into the boat.

Since we felt that we should be a little more concerned about the people who were treating our areas for us, we went to this extreme, if you want to call it that, to protect them. By the way, all of our people administering this program are trained in pesticide management and are certified.

We get about a 25-foot-width swath, and lay the pellets at about 100 pounds per acre. We applied about 6350 pounds of 20 percent active ingredient, 2,4-D. We initiated our control plan on 20 July and basically completed it on 26 July, although it did not take us that many days to actually do the treatment.

As I said, we estimated that at the time we had 600 acres of infestation. We could not get total cooperation from the U. S. Fish and Wildlife Service, nor the Oklahoma Department of Conservation, for the treatment that we wanted. So we treated only about 65 acres of one-time application.

We didn't look at this as being a total defeat because this was the first time we had initiated a program. I think that by working with the State and the U. S. Fish and Wildlife Service, we can increase this application extensively next year.

We treated six areas and we had varying degrees of control. At the same time that we started our control program, we initiated water-quality monitoring by the Oklahoma State Water Quality Board.

We initiated a biological monitoring study with Dr. Couch at Oral Roberts University, and, of course, Dr. Benton has been doing some work for us on remote sensing. We had all these monitoring programs going prior to and during the treatment period.

Conclusions based on our control indicate that the plan was successful even though a limited number of areas were treated. Monitoring data have not been completed but do show that there were minimal effects. We don't feel that we're having real problems from it.

As to the O&M needs which require WES's participation, we feel

that we could use a literature review of all work on Eurasian watermilfoil, as well as the life cycle, compiled in booklet form for the districts to review and become knowledgeable in the procedures used by others.

The second thing we need is guidance from WES on the existing application rates for different types of water-quality conditions, such as Robert S. Kerr which has high turbidity. We feel that maybe some consideration should be made of making the rates a little bit higher.

The third thing we need is technical support from WES in presenting to uninformed agencies information on the use of 2,4-D. We've had difficulty in selling our program and we feel that WES could support us in this from a technical standpoint.

Concerning the future of the District's plan at Robert S. Kerr, we feel that we'll continue with the control plan, basically as we had it this year, except that we'll try to increase the number of acres.

We're going to conduct a heavy public relations program concerning our efforts, with the placement of signs at boat ramps, formal presentations to lake associations, and frequent newspaper articles. This is something that we did not do this year and we feel it is a must. We're going to get with the public a little more.

The last thing, we feel that we'll be flexible and make modifications as needed in our treatment procedures and techniques as new things come up. Also, we'll visit with WES and other districts, and we'll be making changes.

Thank you very much.

PANEL DISCUSSION
HYDRILLA RESEARCH AND CONTROL

by

Moderator - Dr. A. Burkhalter

I'm going to start the panel and get into a brief history. I'm going to try to do this in two types of presentations from the people. We've got those who actually are doing some hydrilla control programs. We'll let them tell you briefly what some of their problems are and some of the techniques they're using in handling them.

Then I have some industry representatives. I'll give them a few minutes to discuss their products, how they're registered, what types of registration, any new experimental products they're working on, and things of this nature.

As far as our problem with hydrilla in Florida, let me briefly say that when you get through controlling Eurasian watermilfoil and you want something else, we've got a new "niche snitcher" that we can let you redesign your whole program around, if you want to.

This plant came into Florida about 1959, probably via the aquarium industry. It was misidentified at first. We thought we had Brazilian elodea. We found out that we did have hydrilla. Most of this early work in the identification and control was done by Blackburn with the USDA.

To give you an idea of the rate of spread of the plant from its introduction in 1959, by 1965 we had an estimated 10,000 acres in Florida and by 1970 we had about 50,000 acres. Today we're probably running somewhere around 200,000 acres, topped, on a yearly basis, and probably around 500,000 acres actually sprigged or in danger of being infested with it.

At about $100 to $300 an acre we can come up with some good cost figures if we ever want to get into a program. We can justify almost any amount of money we can get.

Most of our research to date has been primarily chemical. We have discouraged harvesting, particularly at first, due to fragmentation and

potential spread of the plant. I'm sure, though, that we will be getting back into some of this type of work, probably as time goes on and as we have areas that are totally infested.

PANEL DISCUSSION
HYDRILLA RESEARCH AND CONTROL

by

L. V. Guerra

After all these people with their problems, I feel that I'm kind of lucky. I may have 6000 acres of hydrilla by next year, but it doesn't worry me. I did get some good statistics on it in the fact that I've got a 2.43 reproduction rate from year to year.

On that basis, a thousand-acre lake has created a little bit of Congressional inquiry, so I understand.

Hydrilla in Lake Conroe has created a severe problem. It's a small lake, and the economic losses are in the neighborhood of $30.5 million a year. I have been doing some experimental work.

I have been looking for three things: one, when is the best time to apply; two, what would give us the longest range of weed-free area at an 80 percent level, something that we can live with; three, how cheap can we do this?

We need these numbers and we need facts to be able to come up with some data with which we can put hydrilla under a maintenance control for x-number of dollars a year. I'm setting out plots every month in hope of finding the optimum treatment. We're programming to try to correlate with the plant's growing stage, to know at which time we can treat for such.

Additionally, there is extensive variation from area to area, from water to water. I am guilty of not doing the necessary water chemistry work, but I will be doing it.

As you know, hydrilla is now in its flowering stage and theoretically, classically, this is the optimum treatment time.

PANEL DISCUSSION
HYDRILLA RESEARCH AND CONTROL

by

D. V. Lee

Hydrilla, in Louisiana, was not positively identified until July of 1973, although we feel that it was observed in January of '73.

It was discovered in Spanish Lake, which is near New Iberia, in July of '73. At Sibley Lake it was misidentified in January of that same year.

The areas at which we currently have hydrilla are Lake Charles, Sibley Lake, the Houma area, in New Orleans, Lake Theriot, and Spanish Lake.

The plant, however, is in our Intercoastal Waterways System and from there it can go most anywhere in the southern part of the State.

In the Houma area we're not having any extreme difficulty with the plants, primarily because of high turbidity. It has invaded marsh lakes, like Theriot, a 1500 acre lake, where it was discovered in '74 and is completely socked in now.

We estimate there's approximately 4000 acres of hydrilla, so we're still way behind Florida and hope we never catch up. But we feel that we're going to be fortunate in some respects in that we have high turbity levels and traffic in a lot of the probable areas that it could cause problems.

We're not going to be faced with serious problems in these areas, however, in the marsh lakes we are going to have problems. These are shallow lakes and we do not have the public fishing or hunting pressure in these that will dictate that we do something about the hydrilla problem.

All of us know that most of the itme we can't get anything done until there's enough public demand on the powers that be, usually the legislatures, to come across with the funds to do something. Using that as a base, we're not looking to have to do anything in these areas for some time to come, although we have attempted to.

We realize that the problem is there and we, as conservationists of our state's natural resources, have tried since we found the plant in the state to do something about it. We've set up money in the budget to buy materials that could possibly work, and each time these have been cut out.

We do have one lake where we have done some extensive work with the problem. This is Sibley Lake at Natchitoches, Louisiana, the city water supply for that town.

The plant, when it was identified or observed in January of '73, was observed in association with egeria. You could look and see that that was a different plant. It was identified as elodea canadensis.

In September of that year the infestation had grown significantly and was spreading. In November of that year, we went in with a draw-down. As the water came off the plants, we over-sprayed the exposed material with 2,4-D. After the level reached the maximum amount of draw-down that we were recommending, we went in and chemically treated the remaining portion of the plants, or the remaining water area that had hydrilla infestation, with a combination of Diquat and copper.

In June of the following year we still had a small area infestation and we again recommended to the city that they draw the lake down. We went in again and treated the potholes and the remaining areas. That was in '74 and in '75, '76 the same thing, and this year the same thing. So that's five years of consecutive draw-downs on treating the remaining plants with copper and Diquat.

The new infestations are coming from turions that were produced in 1973, because we have not had any additional turion production.

PANEL DISCUSSION
HYDRILLA RESEARCH AND CONTROL

by

LT COL Phillip E. Custer

Although I am on the hydrilla panel, I'm going to be talking about our entire aquatic plant program, because hydrilla is only one of the many species we have, only one of our problems.

The Panama Canal has been plagued by aquatic weeds since it was first opened to traffic at the early part of this century. The water-hyacinth, especially, was a native plant in the Chagres River. This river happens to be the major tributary to Gatun Lake, which forms the major portion of the Canal through which about 27 miles of the Canal channel passes.

Gatun Lake is in the center of the Isthmus of Panama. This huge freshwater lake is separated from the seas by locks at either end and it creates an unusually good habitat for both rooted and floating water-hyacinths and other submergent plants.

The ship channel through the lake is about 27 miles in length and has a surface area of more than 100,000 acres. For years we've been engaged in the fight to control aquatic plants. However, in the last few years because of increasing nutrient levels in both the Chagres River upstream of the reservoir and in Gatun Reservoir itself, our pest plant populations have enlarged at an alarming rate.

Mats of the rooted aquatic, hydrilla, are encroaching upon our ship channel. Huge amounts of pistia, on the fringes, are being contained behind log booms just outside of the ship channel.

If this hydrilla goes unchecked, in the next few years it will soon be in our ship channel and will be causing problems with our primary mission, which is that of transiting ships between the two oceans.

Of a lesser impact, but certainly of increasing importance to those people who live in the Canal Zone and in the Republic of Panama and utilize Gatun Lake for recreational purposes, is the rapid encroachment of both the floating and submerged aquatic weeds.

Many portions of the lake which had for years been used by recreational sports fishermen are now closed to them. Extensive mats of floating hyacinth are a constant menace to ship traffic through the Canal. If this floating island of hyacinth got into the ship channel it could disable even the largest oceangoing vessel by plugging up the engine cooling water intakes and acting as a barrier through which only the largest vessels could pass.

Current methodologies for control of floating waterhyacinth are spraying with herbicide and mechanical harvesting. Our largest mechanical harvesting operation consists of a Sauerman Slackline Cable, with the conventional dragline bucket replaced by a homemade rake which is capable of lifting approximately four tons of waterhyacinth out of the Chagres River with each cycle. It deposits them up on the bank where they decay.

This particular operation works primarily because we are fortunate enough to have a very unusual site on which we can install it. The hyacinths are contained behind the log boom, which stretches across the river. The cable mechanism is mounted high on a hill. This mechanical harvesting method is, as near as we can determine, probably the most efficient in the world on a dollar-per-ton basis.

Our control program for rooted aquatics, such as hydrilla and coontail, consists of treatment with copper sulphate in the granular form. The chemical is broadcast into the water by hand. It's a pretty messy operation at best, but it does compare economically with any other method we've ever tried.

About a year ago it became obvious that these old methods were causing us to slip in our control of aquatic plants. Although we were holding the annual cost of aquatic weed control to about the same level, the biomass of aquatic weeds in the lake was on the increase.

We contacted the Army Corps of Engineers at Vicksburg to get an idea of what they were doing in the area of aquatic plant control. They were extremely cooperative. Consequently they sent two of their experts, Bob Benn and Louis Decell, to the Canal Zone to look at our situation and give us some advice.

After several days of observation, they told us about some of the Corps' new operations--mechanical harvesting that they were studying in Florida, biological controls such as plant pathogens, host-specific insects such as the *Neochetina eichhorniae*, new and improved herbicides, such as slow-release chemicals that could be handled easily and were biodegradable over a long period of time, and, of course, the thing that is so controversial with all of you, the white amur, or the grass carp.

After a week of discussions with the team from WES on how we could best approach our aquatic plant management program, we decided that we needed to quantify our problem. Accordingly, in January of this year we contracted with the Panamanian Government to fly intermediate elevation infrared aerial photography of the Chagres River and the Gatun Lake area.

This photography resulted in a map showing an infestation of about 1600 acres of waterhyacinth in the Chagres River above Gatun Lake, and a submerged aquatic infestation in Gatun Lake which was estimated at about 12,000 acres, or approximately 12 percent of the total surface of the lake.

Based upon the quantification of our problem, we developed a short-range program consisting of the introduction of biological agents for both field experimentation and operational control, and, in addition, the development and testing of new mechanical harvesting methodologies and field trials of slow-release herbicides.

A short-range program task list was developed and is now underway. We have written an Environmental Impact Statement for the introduction of white amur fish into Gatun Lake in January of 1978.

We are coordinating with WES for introduction of the moth *Sameodes albiguttalis* into our hyacinth population in October, and we are planning to begin a six-month-long field test of the slow-release herbicide E-51, also beginning in October.

While we're trying a lot of these agents and methods, we cannot ignore the fact that we have an everyday operational support requirement for aquatic weed control. Consequently, in spite of all our new tests and our new operational concepts, we'll continue to use our old "tried-and-true" methods of copper sulphate for submergent aquatics; 2,4-D as

a herbicide on emergent aquatics; and, most importantly, with hyacinths, our mechanical harvesting which is so successful.

When we established this short-range task list, it became apparent that the one item we needed to get started on immediately was the planning for the use of the white amur fish. Inasmuch as this animal only spawns in May and June of the year and we wanted to begin the project in less than 18 months, our planning and procurement action was started last January.

We considered many alternatives on how best to procure the fish--whether to attempt to hatch the fish and rear them in the Canal Zone until they were stocker size, or to buy and introduce stocker size fish into the lake from the United States, or to procure fingerlings in the United States and rear them to stocker size in local ponds.

We finally arrived at the conclusion that the best approach would be to buy the fish as fingerlings in the United States and import them into the Canal Zone at the beginning of our dry season, which is January through May.

We will then rear them to stocker size in preselected sites and release them into Gatun Lake when they are big enough to escape predation from other fish. This, we have determined, is our least costly and most efficient approach.

Consequently, we selected as grow-out ponds for the fingerling fish two lakes which are connected to Gatun Lake, or Big Lake, by culverts passing under a railroad fill.

One of these is Lake Calamito. In this 50-acre lake we intend to raise approximately 105,000 fingerling white amur up to about a pound in size to be released to Gatun.

The other, a 10-acre lake approximately one-half mile east of Lake Calamito, will be used to grow-out approximately 20,000 fingerling white amur to stocker size. The hydrilla biomass, plus coontail, is prevalent throughout the pond and should give the fish ample biomass on which to feed during their grow-out period.

In support of getting the fish into the lake, we have had to build a road approximately three-fourths of a mile in length, since Lake

Calamito is located in a very unaccessible portion of a very dense tropical forest.

On the 31st of May we entered into a contract with three fish farmers in Arkansas to supply us with 125,000 fingerling white amur fish in mid-January 1978. These fish were successfully spawned the first of June and are presently being held in ponds in Arkansas and will be shipped to us in January from Little Rock Air Force Base.

In July, WES offered us 300 adult Neochetina bruchi weevils to use in a field trial on our waterhyacinths in this particular backwater. On August 24 we received the insects from Vicksburg and they were put in a five-acre mat of waterhyacinth. The insects, which were shipped to us in ice cream cartons aboard a commercial aircraft, were taken to the field and unceremoniously dumped on to the waterhyacinth. They appear quite happy in their environment and we hope that they do survive and prosper.

It's a little early to make any assessment as to their impact. However, we will be monitoring operational tests and, hopefully, we will have some good results to report in a few months.

Our slow-release herbicide test, which is scheduled for late October, will be performed in one of the backwaters of Gatun Lake. This 50-acre site has ample room to run complete field trials with the herbicide and has added advantages in that it is out of the way of boat traffic and is relatively shallow. In this field test we'll monitor biomass die-off, concentrations of copper in the water, chlorophyll-A and a number of water characteristics to try to assess optimum levels of herbicidal use and to effectively evaluate the use versus cost.

That brings us up-to-date in our program. A year ago I came before this Conference and gave you a short indication of our aquatic weed problems. We've come a long way since then and we have a lot further to go. We feel that the new methodology we are testing and are planning to use will put us on a road to a successful, workable, and cost-effective aquatic weed control program.

Hopefully, within the next few years we will be able to report to you that we have a lake for transiting vessels that is without aquatic

plant problems and is once again restored to full recreational use. Thank you.

PANEL DISCUSSION
HYDRILLA RESEARCH AND CONTROL

by

Nick Sassic

Presently Orange County has the opportunity of utilizing two aquatic plant control agents. Our most prevalent agent or use is chemical or herbicide. We do have the opportunity of utilizing the white amur as a biological control agent.

We presently are working on 800 acres strictly with chemical means or herbicides. This is under a maintenance control type program where we are utilizing Diquat and copper compounds and products of Endothal.

We try and treat--using the theory of Dr. Haller, from the University of Florida--turion and tuber production in the early summer and in the late fall. We found that in the late fall treatment, the period of control is usually a lot longer and lasts a lot further into the summer, whereas before, when we were treating any time of the year as needed, we found that we were having to treat early spring, middle of the summer, end of the summer, and late in the fall.

We have two lakes on which we are not using integrated control, an area which totals about 200 acres. This has drastically reduced the cost of herbicide usage.

We have three lakes in Orange County which are almost strictly under biological control, in conjunction with the Corps of Engineers' Lake Conway Project and the Florida Department of Natural Resources. These are Lake Holden, Lake Ginny Jewel, and Little Lake Barton.

We have approximately 1100 lakes of five acres or larger, and a hundred miles of canals. This potentially gives us about 100,000 acres of hydrilla problem.

Most of our work is done on urban lakes totally surrounded by houses, and economics will not allow us to do all the work that needs to be done in the county as far as hydrilla goes.

What we're hoping to do in the future is to be able to utilize more integrated control with a biological control agent, the white amur,

and thus allow it to be economically feasible to treat most of the area of hydrilla in Orange County.

Thank you.

PANEL DISCUSSION
HYDRILLA RESEARCH AND CONTROL

by

Les Bitting

Old Plantation Water Control District was formed in 1947. At that time the area was almost entirely agricultural. The waterways we deal with are not great in acreage, like some you've heard about, but they are extremely important. All the waterways we deal with are man-made, specifically for irrigation and drainage, especially drainage. We have to move or be prepared to move huge amounts of water over a short period of time.

In our particular area we're not talking about a natural environment where we are principally involved with sports activities or even recreation, although there are some recreational uses. What we're talking about are conduits made to move water in huge quantities to drainage pumps, because we cannot depend on gravity irrigation as a whole.

Our weed control problems began in 1959 when we realized that our water levels were low at the pump and that a mile and three-quarters back we had about a 48-inch or 42-inch water differential. We should have not more than a half-foot per mile lag, so this was really pretty bad.

The problem at that time was Southern naiad. We thought it was the worst thing in the world and that if we could ever control it, we've have it made. It wasn't very hard to control, but we didn't have it made, because hydrilla came in. Of course, this is the thing that really pragues us now.

I want to give you a very brief overview of what we have done and what our present situation is. The brevity of it doesn't detract from the importance of it, as far as we're concerned. We have to do this to live in our area, because the area that was agricultural is now almost all urban, and in a short time it will be completely urban.

A few years ago, in the beginnings of our efforts with hydrilla,

we used aromatics and killed hydrilla and fish and all kinds of things. Now we've learned better. Of course, this was a very bad situation, but as time went on and pressures to do better were on everyone, research came to our rescue.

In the first efforts we used nontoxic materials, copper sulfate and Diquat. This was expensive, erratic, and it didn't do a very good job. We finally got to the Chelates but about the time the Chelates came on the market we also began to use inverts.

While our areas are small, they are about 110 percent filled with hydrilla, because they came up out of the water that much. There just wasn't room for any more in the water.

Of course, we had a period of dry years in there. Our needs for draining were not as severe as they had been and have been in this last year. When we finally got around to using and trying inverts, our practice for the past years has been to use two gallons of Diquat, four gallons of Chelated copper in an invert emulsion, placed in the water with hoses that run as deep as we can make them go. To say that they are deep-running hoses is sort of a misnomer if you have hydrilla at the top, because the hose doesn't go to the bottom. But we did the best that we could.

This has resulted in the fact that in the last three summers we have looked very good. We're not rid of hydrilla, but it's out of sight where it does no damage and is not harmful to us. We are on a maintenance basis.

In the beginning we did not know the theory of fall tuber production. I'm not sure that that's the case in Florida. It may be; I wouldn't say. I question it.

When we finally got to the point where we could make an inroad on hydrilla or an impact on it with a treatment, we hit it again and we just stayed on it. In some areas we have treated it as much as four times a year, in the beginning. Now our areas that were the worst look good.

The last treatment was about ten months ago. We have come to the point now where we are putting very little herbicide in the water. Of course, our costs are going down, and our waterways are what they ought

to be. We appreciate the efforts of researchers and, I think, this is where our salvation lies in the future. It's real research.

PANEL DISCUSSION
HYDRILLA RESEARCH AND CONTROL

by

Doug Powell

Pennwalt presently has three endothal products which are used for hydrilla control under certain instances: Hydrothol 191, which is a monodimethylalkylamine salt of Endothal; Aquathol K, which is the dipotassium salt; and Hydout, which is the granular form of 191. These are presently used in certain specific instances.

When 191 and Aquathol K were originally labeled, about 15 years ago, elodea was on the label. A lot of the work in Florida was on elodea. Then, elodea was changed to hydrilla, but the label wasn't changed at that time. As a result, for these products to be used, you have a state-local need label. In Florida that is now the case for Hydrothol 191, and Aquathol K is being applied for.

A new, updated label has been submitted. When this will come back, it's hard to say--six months to a year.

Hydout, the granular, slow-release type pellet, is not federally registered. It is registered only for use in Florida, Georgia, and Texas.

The Endothal products, as I said, have been around for a long time but they are relatively new in a lot of cases. Pennwalt is continuing research now and we've got field plots out in Florida and Texas and in other areas, working with some different combinations, some of the polymers, weighting agents, etc. Hopefully, within the next year some updated information on the Endothal line of products will be available.

PANEL DISCUSSION
HYDRILLA RESEARCH AND CONTROL

by

Charles Hargrove

First of all, I'd like to say, in following up with what Les (Bitting) had said about the inverts, that we do make one of the inverts that's been used extensively in Florida, which is our Visko-Rhap system. I'm sure that many of you have used it over the years in terrestrial-type work.

In Florida, it's kind of getting to be "old hat." We've been working with it for about six years now. One of the advantages, if you're using an underwater invert, is that it doesn't diffuse throughout the water column.

As you know, an invert is a water and oil emulsion and you can tie it up where it is very tight so you get a slow release of your herbicides into the water, which is an advantage. Chevron Chemical, in working with Diquat, has been so impressed with it that they're planning to put this on their label. We have been able to make Diquat work in certain situations where in the past it would not work.

A big advantage for a maintenance program is that it stays where you put it, because it's heavy enough to drop to the bottom. You do not get the diffusion throughout, as you do with conventional type emulsions. For example, if you're doing a ditch bank and you put a conventional application out, most of your herbicide will be falling into deeper areas. With an invert, you can put it into the intrasill water and keep it where your maximum growth will be.

But I did just want to bring you up-to-date in case some of you are not familiar with the underwater inverts that we've been using. It's just a new technique to make some of the herbicides that we do have labeled a little bit more efficient and less costly for the application.

I was also asked to make mention of a new herbicide that Rhodia is developing, which we are very excited about. It's called Azulox. Its technical name is Azulam, and it's one of the carbamates. We

already have it for labeling, for sugarcane and non-crop. We are, at the present time, waiting for EPA to release labeling for ditch banks. Azurlox is a very selective herbicide that is slow acting. Its mode of action is that it's translocated, it's strictly foliar absorbed, short residual. It moves from the foliage into the root system and from there it goes to all of the meristematic tissue in the plant and starts killing from there.

It takes, in terrestrial-type weeds, something like three weeks to even see any activity, but it's very thorough on the plants it does control.

We're in the initial stages of working with hydrilla with Azurlox. Initial tests show that it does translocate into hydrilla and in some of the work it has killed the complete root system.

Thank you very much.

PANEL DISCUSSION
HYDRILLA RESEARCH AND CONTROL

by

George E. Worthley

Nalco Chemical Company has been working with the polymers for the last five or six years. We have a product called Nalco-Trol, which is a polyglynol polymer, a long, straight-chain polymer. It's designed for application for drift control.

This past year we've come up with another polymer which we've designated a nalquatic. I like to call it a non-invert invert. It basically is wrapping the herbicide up inside of a polymer and getting a slow release.

We're also working on using straight polymer with straight chemical to put out, which looks very good at this point. We'll be looking at different types of polymers.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Moderator - R. P. Clark

Winston Churchill said one time that the maneuver which brings an ally into the field is as serviceable as that which wins a great battle. These Corps of Engineers "maneuvers," if we may call them that, of having meetings such as this may bring active allies into the field of battle against aquatic weeds. To paraphrase another of Churchill's statements, that we will fight them on the land and on the sea and in the air, perhaps we can say that we will fight the weeds with biological control, mechanical control, and chemical control. We are ever searching for a combination of these tools with which we can successfully win the battle against the weeds.

Obtaining the tools, especially chemicals, is often a battle within itself. The work required to obtain a chemical is hard, and the rewards are often few. Therefore, any ally we may bring into this effort may be the one that helps win the battle.

I sometimes believe that in our concern for controlling aquatic weeds, we fail to remember that our initial purpose was to protect the environment. In our efforts to kill the weeds, we sometimes kill the weeds and the fish and anything else that may be near.

The need for chemical control is obvious, the development is difficult, and retaining what chemicals we have may be as difficult. Therefore, we must all cooperate. This panel is to discuss some of this effort in developing and maintaining chemicals.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Carlton R. Layne

In '72 the amendments to FIFRA (Federal Insecticide, Fugicide, Rodenticide Act) that were added by Congress mandated that all pesticides be re-registered, and the supporting data that is on file in Washington must meet the requirements of the new Section 3 registration regulations.

When the existing products began to be re-registered and reviewed, it was learned that many products had been previously registered with minimal data or in some cases no data at all. As you are aware, to cancel a pesticide involves a lengthy proceeding in court with a judge, involving the registrant of the pesticide. Only the registrant is permitted to submit evidence, so EPA came out with what is commonly known as R-PAR, or RePAR I have heard it called, rebuttable presumption against registration.

This provides a vehicle whereby the public can be actively involved in the preservation of pesticides. When data gaps are discovered in a registration, an R-PAR is published EPA and any interested party can submit data.

There are really three things that you go by. First of all, we want to fill any data gap in the existing registration on behalf of the chemical. You also are required to consider the risk versus the benefit, and in the hearings, data can be submitted to EPA, supporting either the risk or the benefit. If the product was restricted, we must consider that. If the product was restricted, would this lessen the risk?

The obligation exists, along with the responsibility and the opportunity, for anyone who wants to keep the few chemicals available for aquatic weed control. You must submit your data supporting the benefits and the continued registration of them. This process is of a continuing nature.

The use data is very important. This would include your application techniques that might vary a little bit, your water-quality

analysis on a continuing basis, and the effect of the chemicals on the non-target species.

These various aquatic chemicals must then be documented as far as all the different uses; this applies to all pesticides. It is easy for us to sit here for three or four days and listen to strictly aquatics, but be reminded that the federal law applies to all pesticides, disinfectants, insecticides, fungicides, the whole gamut.

I think we will all agree that the products that do cause adverse effect on the environment or present possible health hazards should be cancelled or should be controlled more stringently. But it would behoove all of us to keep in mind that unless we are prepared to go to EPA when the rebuttable presumptions are published, with data supporting the various uses we have for the products and try to fill the gaps in the data, they just may not be around much longer.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. Donald Duffy

My speech will be a brief follow-up to what was said by the previous speaker. I will give a brief update on the status of the aquatic petitions that are on hand in the agency at the time.

As you know, when there is a reasonable expectancy that an aquatic use will lead to residues in meat, milk, or fish, shellfish, or treated water entering a potable water or drinking water system or used in irrigated crops, then there is a need for tolerances.

The following five pesticides have regulations which have been issued as of the first of September. First there are the copper compounds, the copper sulfate pentahydrate, the basic copper carbonate, and the copper triethyanolamine. In connection with these uses, there is a one part per million tolerance in potable water and exemption from the requirement of the tolerance for the raw agricultural commodities.

Then we have Xylene, which is registered for use in irrigation conveyance systems with an exemption from the requirement of the tolerance.

Simazine is registered for use in farm ponds with little or no runoff and there is a tolerance in fish and in potable water.

Then we come to the various 2,4-D tolerances. The Corps, of course, has one for waterhyacinth control, the dimethylamine salt, and they have a tolerance in irrigated crops, fish, shellfish, and potable water. The Bureau of Reclamation has the irrigation ditch bank treatment in the western United States with the dimethylamine salt, and they also have irrigated crop and potable water tolerances.

Then there is the TVA, which is registered to use either the dimethylamine salt or the BEE ester for watermilfoil control in the TVA system, and there is a fish and potable water tolerance in that connection, too.

There are two herbicides, Diquat and Endothal, which are in a

special category, you might say, in that they have interim tolerances for potable water. So in a sense, they are covered where they have restrictions that will prohibit use where there might be a problem with irrigated crops, etc.

In conjunction with that, you also have petitions in house, and the Corps has one, of course, for use of Diquat in ponds, lakes, and slow-moving water. That is held up at the present time within the agency because of an internal policy discussion. For Endothal, there is a petition in house which is held in abeyance pending development of additional data.

Monsanto has a glyphosate. They have an experimental use permit for temporary tolerances in connection with the use of glyphosate in irrigation water. They are developing additional data and, as I understand it, will be coming for permanent tolerance.

The Corps has a 2,4-D BEE petition in for watermilfoil control for which we are asking for additional data. That is, of course, at a higher treatment rate, and we are asking for additional data on dissipation of residues in water and also on residues in shellfish.

Various other petitions have been submitted and are being held in abeyance. There is a Silvex petition by the Corps, for Dichlobenil. There is a Dalapon petition by the Bureau of Reclamation, for use on irrigation ditch banks. There is a draft order which should be coming out shortly. There is just a little clarification we have to have in the usage.

Last, I might mention Fenac. We have an Amchem representative on the panel so I am sure he will discuss this. They were in previously for a tolerance which was withdrawn, and now they are in for an experimental permit which hopefully will issue shortly.

That is about the extent of the tolerance situation in EPA. Thank you.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. Kerry K. Steward

I think probably it would be most meaningful to go through and very briefly explain our involvement in the development of technology for chemical aquatic weed control. That is basically through our involvement in a screening program in a search for new chemicals for use in controlling weeds. We are one of three labs, with the Agricultural Research Service, that has this type of program. The other two are in Denver, Colorado, and in Davis, California.

Our program at Fort Lauderdale has been in existence since about 1961. Over this period of time nearly 4000 chemicals have been run through the screening program. About everything that is being used in aquatics and that is registered has gone through that program in one form or another.

Our last name is Service, Agricultural Research Service, and this is an actual thing that we do. We are one of the few agencies, I think, in the federal government that can accept money from other agencies, federal and state, in order to conduct research.

We have a policy established whereby we can obtain chemicals from industry, on a confidential basis, through a cooperative agreement which is legally binding, which enables us to assist industry, or anybody else for that matter, in development of these products.

We are in the business of collecting the support data that is required in order to register a herbicide.

The product that you as the consumer use is the herbicide. In order to use that product you have to have a permit, which is essentially the label on the product. Collecting the data, from the time the material is synthesized by industry or universities to the point where you have a label and you can use it is a long, tortuous process. We are also involved in collecting some of the efficacy and residue data, supporting these labels.

In our screening program we bioassay various materials, chemicals, and herbicides against various problem species. We have approximately 1000 square feet of laboratory space, growth labs, greenhouses, and screenhouses, where we bioassay these materials. We now have probably about two acres of outside area set up with large aquaria, where we can continue various phases of the screening program under outside conditions. We have the facilities, equipment, and expertise to carry these materials into the field where we do further evaluation.

We need new, safer chemicals. There has been a dry-up, I think, of our supply of new materials which are required in order to make the progress in this technology that we need to solve our problems. I don't think we can do it unless we get some new materials to work with.

A lot of things are involved. Part of the problem is the registration process. It is a cumbersome, expensive process, and it has retarded the development of new materials. We need to do something about that, and I think we are addressing the problem today.

We need very much a good estimate of the extent of our problem nationwide, specifically to be able to justify the funds and the manpower that we need to solve this problem. Thank you.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Edward Pack

Our current work at Syracuse Research Corporation involves studying the fate of Fenac in the aquatic environment, through an understanding of some of the physical, chemical, and biological factors which may influence the environmental system.

What the study attempts to do is separate each factor which may influence the degradation from as many as possible of the other factors, and at the same time adhere as closely as possible to EPA guidelines for what information is needed for the registration. The data that we are acquiring will be used at least in part to obtain registration for Fenac as an aquatic herbicide.

One of the areas that we are studying is chemical hydrolysis. In chemical hydrolysis, as in all other areas of the study, we are using pH values and temperatures that simulate the natural environment. In particular, with Fenac we have found that in three weeks, at pH's between five and nine and temperatures between 10 and 30, we didn't have any degradation, which is about how all the other studies have turned out so far.

One of the other ways the compound may degrade in the environment is photochemically. For a given period of time each day, which varies with the location, the season of the year, and the depth in the water, the chemical is exposed to the sun. Light energy may be used to cause a chemical reaction which would not normally occur.

Fenac has been studied in the past but with very impure material. We have redone the earlier studies with purer material, and we found that in our own photoreactor we were able to get Fenac to disappear below detectable levels in 60 minutes. However, the light we were using at the time contained considerably more ultraviolet light than natural sunlight does.

Having shown that we could degrade the material, we went back, put

a filter on our lamp to filter out those wave lengths the sun doesn't have, and attempted to photodegrade Fenac again. We found we couldn't do it any of the water that we had in the lab.

It has been recorded that photosensitizers do speed up the degradation of chemicals in the environment, which, at least for aquatic herbicides, could be important because they are invariably put into water that is very green and probably has a lot of photosensitizer. We went out to a few of our local lakes and tried again with lake water, and we still couldn't get it to degrade.

We started introducing our own photosensitizers, natural photosensitizers. In this case we were using FMN, which is a riboflavin phosphate found in the environment. We were able to get Fenac to degrade; about 75 percent of it had disappeared in 24 hours. We ran into a few problems at this point, however, because the FMN was degrading faster than the Fenac.

We are presently looking for other photosensitizers, also natural photosensitizers. There are a lot of photosensitizers that are mostly chemical and we probably wouldn't find them in the environment. We hope to be able to find environmental photosensitizers that will work.

One of the other areas that we are looking at is the adsorption and desorption of the chemical. To do this, we use four typical bottom sediments provided by WES from reservoirs and lakes throughout the southeastern United States where the chemical will probably be used.

The experiments were done, as were most experiments and all the experiments we will be doing, at two parts per million, which again is the concentration of the chemical in use. Basically, to study adsorption, all you have to do is shake up the bottom sediment with buffer solution containing carbon 14 labeled chemical and monitor the disappearance of the chemical from the solution. What disappears from the solution is adsorbed to the soil.

We did the experiments at environmental pH's between four and nine and with all four sediment types and found, as expected, Fenac did not really adsorb very strongly at pH's of between six and nine. We are only getting between three and 11 micrograms per gram. At a pH of

four, however, which is considerably closer to the pK, we were able to obtain about two or three times as much Fenac adsorbed to the soil, which could mean in an acid environment that a lot of the Fenac you put on the water will stick to the sediment.

We are also doing, as part of the entire program, microbial studies. We are doing these a little bit differently than we have done in the past. We are using five-gallon aquariums that have about equal volumes of bottom sediment and lake water. We are introducing Fenac to the lake water at two parts per million and them monitoring its disappearance from the water over about six or seven months.

We are keeping this in an environmental chamber that is maintaining about 18 degrees Centigrade, so that we are hopefully simulating the microbial conditions that Fenac will actually be under in the environment, on the bottom. To date we were able to see about one-quarter of the Fenac disappear in the first week, but we believe that most of that is just adsorption to the sediment.

We also will be doing microbial studies in anaerobic systems, because quite a few lake bottoms are anaerobic.

We are going to look at Fenac in sediment counts because it doesn't adsorb to the sediment very well. In lakes where you get a lot of water flow through the bottom of the lake instead of out the river, you may run Fenac into ground water. So it is important to know what it does as it flows through a sediment count.

We are going to look at the ion water partition coefficient, which is a general measure of how the chemical will partition into living tissue.

After doing that we are going to take a look at some living tissues, fish, daphnia, phytoplankton. We are going to look at some of the aquatic plants and watch Fenac act in those and see what happens to it. At the end we are going to put everything together in a model aquatic ecosystem and follow it through.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

W. D. Hogan

As the guidelines of EPA continue to be more limiting, to protect your environment and mine and everybody else's, all of us are faced with an increasing opportunity to share in this joint development of biological chemicals that we can use for aquatic weed control.

This joint effort is possible only if the people in this room work together. Industry cannot carry the cost alone. Depending upon what era you came along in, the cost of developing an agricultural chemical or an aquatic weed herbicide from scratch, from phase one which is the unpatented product right on up to the open market, would range from half a million dollars up to about $15 million today.

What I am talking about has always been a joint effort between the manufacturer, the reasearcher, such as the U. S. Department of Agriculture, our state and federal agencies working together, and the private consumer, who in many cases has contributed more than industry in this program.

This is a continuing effort even on a product as old as Diquat. Chevron offers this material under a special marketing arrangement with Imperial Chemical Industries of England. Diquat has been around approximately 15 years, but today we are continuing to evaluate it on the basis of improved methods of application, reduced rates. We are looking at such things as improved carrier systems, water being obviously the cheaper, but also invert emulsions and polymers and materials of this type.

In the general discussion somewhere, we also ought to think about one thing. One of the stumbling blocks is that we don't know very much about the plant physiology.

How do you control something that you really don't know a whole lot about? If we were trying to control mosquitoes in the Panama Canal Zone that way, we would still have yellow fever there. That is why we

still have hydrilla and waterhyacinth after all these years.

Thank you.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Warren Davis

I am the senior registration coordinator for Amchem Products, now a division of Union Carbide. Amchem has a fairly strong dedication to aquatic weed control and we realize there is a very good market there. We are quite proud of the accomplishments we have had during the past two years, despite the great difficulty of securing federal registrations.

By working with the Corps of Engineers, by working with TVA, by working with the Bureau of Reclamation and Department of the Interior, we were able to secure the first registrations for Weedar 64, which is a dimethylamine salt of 2,4-D for use on waterhyacinths and milfoil. We also were able to secure a label amendment for Aqua-Kleen 20, which is a butoxyethanol ester formulation used by TVA in their water systems.

In addition to the phenoxies, we are very excited about a proprietary compound that we have which has a multitude of uses, including sugar cane and terrestrial weed control. The product is Fenac 2,3,6-Trichlorophenlyacetic acid. This compound has been used in limited testing in select areas in the country and we have found up to 100 percent control of hydrilla. We have also seen a tremendous suppression of tuber formation.

Based on these very encouraging limited field tests, we filed on July 13 an application for an experimental permit with the Environmental Protection Agency. We requested 37,000 pounds of the compound, which is a 10 percent material, to be used in the states of Texas, Louisiana, Florida, Georgia, and South Carolina. We have received excellent cooperation from the Corps of Engineers in setting up what we feel is a very manageable control program, which we feel will generate a considerable amount of information to give us further guidance as to a second year of testing for this compound.

I will give you a little insight into some of the difficulties

that we are facing under the R-PAR re-registration data validation system.

EPA is in a process now of very frequently making allegations, not necessarily based on total data banks, that compounds are hazardous. This is where the R-PAR system developed. They are also in the process of reviewing all data, a situation which was pretty much generated by Senators Kennedy and Moss and some of their confrontations with EPA.

All of the data is being reviewed, based on the new Section 3 guidelines. What they are going to find is that many of the proprietary compounds used in aquatics and terrestrial situations have data which are not in compliance with any Section 3 guidelines. The result is probably going to be a conditional registration of some sort, and under this conditional registration the prior registrants will be asked to generate new data in compliance with the guidelines.

This is all well and good until you look at the magnitude of the data that is going to be required. It is going to be staggering, and in very many cases the market potential will not be sufficient to require the investment of capital necessary to do these studies to maintain the registrations.

I think we are going to see quite a few products go by the wayside, not because there is any known hazard, not because they present an imminent threat to man or the environment, but basically because industry as a profit-oriented corporation cannot afford to put money into situations where the return won't be significant.

To even further complicate the situation, under FIFRA as it is currently outlined and through some internal working situations of EPA, they have a set-up where the first company to supply the data does not necessarily have nay protection for that data.

Once the data requirements are filled, the second company, not necessarily an innovative company, may file a submission, make an offer to pay, and secure registration. What they are actually doing is selling material, gaining a profit, actually taking some of this profit away from the innovative company while either paying compensation or fighting a legal battle to determine what the legal compensation is.

Under the FIFRA oversight, hearings which are taking place in Washington now have the advantage of a small section that was built-in, which could be highly beneficial. What this would do is allow for a five-year period of confidentiality for new data submitted to Washington in order to maintain a registration. This is basically a five-year lock for the innovative company.

This isn't to say that if two companies have a similar product they can't both submit the data. Nor does it say that the company that generates the data can't license or allow other persons to use that data.

The second five-year period will be a mandatory licensing scheme that EPA would institute, where this data would be available to anyone who wanted it, but compensation would be paid to the innovator of that data. If the compensation situation can be resolved between the two companies or two or more companies looking at that same data, there is no problem. If it can't be resolved, it goes to binding arbitration by a federal arbitrator. After that period the data is basically open for public use.

We are fairly enthusiastic on this because it does at least give us some degree of protection and to some extent allows us to recoup the very significant investment that we will be forced to make in order to maintain any arsenal of pesticides for you to use. Thank you.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. Frank Harris

As most of you are probably aware, we have been involved in research aimed at the development of controlled release pesticides, and particularly controlled release aquatic herbicides, for the past several years. During that time I feel we have progressed from what I may call pure basic research to the point where we are now prepared to turn out rather large-scale quantities for field tests. In fact, we have several formulations undergoing field tests right now.

The formulations we prepare can be broken into two rather broad categories. One is what we like to call our physical formulations, or physical carrier systems, in which we have an aquatic herbicide physically incorporated, simply trapped, in a polymer matrix. The release mechanism in this case is usually a diffusional process whereby the herbicide slowly diffuses through the carrier into the environment.

Under this system we have a Fenac polyethylene formulation that is in its second year of field tests at the University of Southwestern Louisiana.

We also have other formulations in this category that are ready for testing. We have looked at a lot of new carriers other than polyethylene. We have in the past year tested several formulations that are based on naturally occurring waxes. We have beeswax formulations where the beeswax serves as our carrier, and we have incorporated into beeswax several herbicides, including Fenac, 2,4-D, and the like.

Under our second category or second type of controlled release device we have what we call a chemical system. In a chemical system the herbicide is actually chemically attached to a polymer backbone and release occurs by a hydrolysis mechanism where the herbicide is slowly hydrolized off the backbone into the environment.

There are two different ways to prepare these. One would be be actually taking a herbicide and converting it into something that

could be polymerized, herbicidal monomer, and then polymerizing it and forming a polymer. Or you can take a preformed polymer and chemically react it with a herbicide. We have looked at both of these approaches, probably the first approach in greater detail.

In these types of systems we have particularly paid attention to 2,4-D and Fenac. 2,4-D has probably been the one we have worked with the most. We have converted that into a whole series of polymerizable monomers, went ahead and polymerized those and made the polymers, and then studied the rates of hydrolysis.

We have also made a lot of co-polymers, where we have varied the actual composition of the polymer by adding another monomer that in effect varies the end release rate. Some of these polymers are being tested right now in Colorado by the Department of Interior. We have looked at these at the University of Southwestern Louisiana, also.

During the past year we have looked at a lot of new co-monomers and determined a lot of new release rates on systems of that type.

On the second way of preparing these, where we take the preformed polymer and react it with a herbicide, during the past year we have looked at the reactions of herbicides with a lot of inorganic polymers, the silicates in particular. We are looking at reacting herbicides with diatomaceous earth. Modify the silicate a little bit, react the herbicide with the silicate, and then go ahead and determine the release rate.

We feel this has some real advantages in that diatomaceous earth is very inexpensive and might lead to a really good system. We have also worked with cellulose, particularly carboxymethyl cellulose, and reacted that with herbicides. Now we are looking at the release rates on these systems.

So, in conclusion, I would say that what we are doing right now is really gearing up for field tests. We are making formulations in kilogram quantities. We are supplying these to the Corps and the tests are currently being run. We are hoping that we are not too far off from some really large-scale field tests. Thank you.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

George A. Janes

Churchill is credited with saying one time, "My tastes are simple, I like only the very best." We like to feel that way about controlled release.

At Creative Biology Lab we make model compounds for the Corps of Engineers. We check the controlled release (CR) properties of these compounds in a practical way, looking toward the problems that will be specific to CR compounds. We then take the more promising candidates into production runs.

In our current program we have made 144 model compounds out of some seven basic polymers and nine active agents. We also are participating with the University of Lafayette, Drs. Barry and Foret, on the pool tests. We are working with Colonel Custer at Panama, going on a 3000-pound controlled release copper material that we hope to test down there.

One thing that I think would be worthwhile to emphasize is that we in the controlled release field have very carefully stuck to the words "controlled release" as opposed to the term "long-term release" or "slow release," that were used in the past.

In the term controlled release, we mean just that. We are controlling it for some purpose or another. I believe it is safe to say that to date the work that we have done in aquatic herbicides toward controlled release would apply equally well if we had been doing the work for EPA, because their problem is controlling the release of these agents into the water system. You have to make model compounds and you have to release these materials at different rates, at rates that were not practical to do before, in order to evaluate what effect they will have, if any, good, bad, or indifferent, on the environment.

Naturally we feel that being able to slow down, change, alter the delivery systems is going to enable us in the long run to go to the

least damaging introduction of toxic agents into the environment. I think we all have to agree that anything in the environment is damaging to some extent.

Our toxicology standards are based upon acceptable tolerance levels, where the benefit is weighed against the harm. It seems to be obvious that we are going to have to go that way as the population and economic pressures keep building up on us. We are going to have to weigh everything we do as benefit versus harm or potential harm.

Certainly we know that without items like chlorine in the water system, we would be in sad shape. But I believe all of us think that if we could selectively have water without chlorine, we would probably as individuals be a little better off, although as a mass population we would certainly be in sad shape.

I think also that it is important to consider controlled release being just an extension of the variations we have been using for years. We have been manipulating delivery systems, as we can, with nozzles, with sub-surface releases, with pellets, with emulsions, with drift reduction additives, and now we are taking this one step farther, where we can release the material into the water system at one time and have the active agent come out at what we determine as desirable rates or most desirable rates. Thank you.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. J. Robert Barry

Over the past several years, we have tested a number of experimental herbicides and standard herbicides that are in use and made recommendations. In the past two years we have been contracted with the Corps to study and determine rates of application and usage of controlled release herbicides.

Those that we have concentrated our efforts on include a rubber copper sulphate monor hydrate combination, containing 17.5 percent copper ion, with a release life of five to seven months.

Another was a rubber 2,4-D combination containing 18.7 percent 2,4-D BEE with a release life of up to two years. We also tested a material that we call the Fenac wafer. It looks like a little red wafer but it is in polyethylene, including a Fenac formulation containing 20 percent Fenac acid, 70 percent polyethylene, and 8 percent iron oxide.

In 1976 we attempted to bracket rates which were effective and we found that in many of the species upon which we tested these materials, we eradicated the species in our plots. In order to determine chronicity, chronic levels that would hold the weed in abatement, we decided to reduce these rates for the 1977 studies.

At this point we are in the process of analyzing our water samples so that we can correlate water residue levels with degrees of control. We are also making visual ratings of the weed control that we are getting at this point. It is a little early to determine results of our 1977 tests.

We intend at the culmination of the experiment to extract all weed species and get weights on these. We can also correlate this with our residue studies.

We work with plastic pools, excavated and lined with black polyethylene. The aquatic species are egeria, hydrilla, Eurasian watermilfoil, coontail, and waterhyacinth. The submersed species are

established in flats containing one-half silt loam soil and one-half peat moss.

In one particular pool we used Fenac wafer at 30 parts per million formulation. We got good control of egeria, abatement of hydrilla, complete control and eradication of Eurasian watermilfoil, eradication of coontail, and eradication of waterhyacinth with this level of Fenac.

With the 2,4-D rubber combination at a rather high rate, we did not get control of species like egeria and hydrilla, but we did eradicate Eurasian watermilfoil. We also had good abatement of the waterhyacinth. So, these herbicides normally work in the controlled release form and normally are effective on species that they would control in the standard formulations.

Copper had a fairly broad spectrum as far as the species that we are concerned with. At the high rates we used in 1976, rates up to 100 parts per million of formulation, we were able to eradicate several of the aquatic species, and we got severe abatement and almost eradication of waterhyacinth, as well.

In summary, I would like to state that we are able to obtain very desirable results in pools with these controlled release herbicides, and I feel that many of them merit further testing in field situations. We have done what we can in pools with these three herbicides and it would be very interesting to see what they would do in open situations.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. Charles McCormick

Our research at the University of Southern Mississippi in the polymer science area has been mainly based on controlled release polymers. Our specific emphasis has been on biodegradable polymers and also herbicides which potentially will degrade by UV (ultraviolet) light. We think that this is going to be important in the future for acceptance of these systems.

Instead of talking about controlled or slow release, we, too, like to talk about controlled activity, because that is indeed what we would like to do. Most of you are aware of some of the advantages of controlled release systems. I think the main thing that we are trying to do is, obviously, limit the amount of the herbicides which will be required and enhance the environmental safety of these materials.

As has been mentioned, one of the two types of controlled release is physical entrapment. Most of the systems which are available commercially today are based on a pesticide dispersed in a polymer matrix.

Our particular work involves hooking already available pesticides which have proper functionality to a macromolecular polymer backbone which is biodegradable. Then we have the action of either bacterial or chemical hydrolysis to release the pesticide itself. We feel that the existing pesticides are the ones to work with because in releasing a pesticide which has already been tested in the environment, we are a little bit ahead in developing commercial systems.

I would like to point out that it is very important for us in academic institutions to have the input of industry, regulatory agencies, and users such as the Corps, in order to come up with some idea of how to design our systems. I hope that some of the questions will address this problem of determining the amount of pesticide that is required, the amount of herbicide needed to maintain a low level of aquatic weeds.

In our particular system we have been working mainly with four

pesticides. This is based on the fact that these have either amine or carboxylic acid functional groups which we can attach to the polymers. Our most significant work to date has been done with Metribuzin, or Sencor, which has been used almost totally terrestrially. I understand, though, from the people at Chemagro, who make this Metribuzin or Sencor, that it is very active in the aquatic system. It also has a big advantage in the fact that it will quite rapidly UV degrade all of its heterocyclicamine compound, and all of the products which it breaks down to are present in the environment already. So we don't have any chlorinated compounds to worry about.

The polymer substrates that we have been using are based mainly on economics, of course, on the large availability of cellulosic materials, waste products from various processes. We have a grant from the Department of Commerce through Sea-Grant to look at chitin as a controlled release material. We have used Chitin and have successfully attached 2,4-D to it and are presently studying the rates of hydrolysis from it.

Another material which is similar to chitin, chitisan, in which we have an amine group, is being looked at. There is a pilot plant being built in Plaquemine, Louisiana, by Dow to produce this, so these materials are all biodegradable and environmentally acceptable.

Dr. Ken Savage, who is from the Agricultural Research Center at Stoneville, Mississippi, has been doing tests on our terrestrial systems. We have carried out several in-house studies on rates of release and it just so happens we have done our initial studies in water.

We know that we can control the release of the herbicide in water by changing the polymer properties. One example is polyvinylalcohol Metribuzin, which is a biodegradable system. We have a couple of patents in this area and are looking at pilot commercialization with Hopkins Chemical Company in Madison, Wisconsin.

These particular systems can be varied to give different rates of release. Other studies have been done in which the pure formulated compound metribuzin, as it is normally put down terrestrially, is compared

to some of the controlled release formulations in terms of weed growth versus time and days.

We have been able to significantly increase the efficacy of the herbicide in the controlled release systems to about 80 days with one particular system. This is compared to the very rapid breakdown for the metribuzin due to, we think, several mechanisms of volatilization, UV degradation, and leaching. If we can increase the longevity of this particular herbicide and yet keep the rates much lower, then we think we have made significant progress.

Another problem with this particular herbicide is the fact that the rates that are required due to its rapid breakdown, the rates that are required for a growing season, are so high that they actually damage soybeans in which this is used to quite an extent. We are quite interested in taking a look at this system in the aquatic environment. The Chemagro people, who make Sencor, are interested also, not only from a terrestrial point, but from the aquatic standpoint. Thank you.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

John Ingraham

What we have been doing for the last three years is working on the anti-drift concept, working with our product known as Nalco-Trol. This product is exempted from a tolerance and falls under Paragraph 180.1001 of the Federal Code, which means that it can be used with any pesticide on any crop.

My comments will be directed to our drift control concept and presenting some of the efficacy data that we have collected at a number of different universities, and then also our plan for taking a look at this product, how it can be used in the Corps of Engineers, and getting that data pulled together.

We are working with a Bathan nozzle, which is probably the easiest to work with from a drift control standpoint. We hardly have any drift associated with this. We can modify the actual spray as it comes out the nozzle. At a magnification of 15- to 20-fold we can observe the actual edge of the fan spray. We are concerned about what we are doing with this edge, about the ligaments, and also the little particles as they are formed.

Of course, what we want to accomplish is to get the particle down to the targeted area in particle form. One thing we have to be concerned about is the size of this particle, as far as its drifting off the targeted area. We also have to be concerned about its rate of evaporation, which is directly related to particle size, the relative humidity which we are spraying under, and also the temperatures.

This system is very easy to condition; it really doesn't drift that much. For instance, if you would take all of the average figures, with and without the Nalco-Trol conditioning concept, you would see that in our targeted swath we can achieve 87 percent of the material to be in that targeted swath and we would lose about three percent of the material. If we were to spray a field one-quarter mile, we would pick

up about three percent in downward drift.

With our concept, we can reduce that to a quarter of a percent, or get 95 percent of the material on the targeted swath. You must remember, though, that in this type of system we have a lot of things working for us. The height of release is very low. We are releasing the material about 20 inches off the ground. Our spray pressure is very low and our advance speed of the tractor is very slow, about three miles an hour.

We have a different type of challenge when we get into aerial application. We fly the herbicide, or pesticide or defoliant, at about 110 miles an hour. Height of release isn't too bad, about ten feet off the ground. If we would have this type of system, again what we need to do is take a look at how much we are getting into the targeted swath. We have done efficacy data to help represent this.

We have applied Kocide right down onto the top of sugar beets. What we are going to do is measure the amount of material in the targeted swath.

We will be putting downwind sampling stations to pick up the amount of 2,4-D amine from the targeted area. We will use a discipline known as gastrophotography to analyze how much material we are actually getting into the targeted swath versus outside the targeted swath. Thank you very much.

PANEL DISCUSSION
CHEMICAL CONTROL TECHNOLOGY DEVELOPMENT

by

L. V. Guerra

Our research involves the utilization of all these ideas that we hear at these meetings. I pirate things, make a little note, talk to people, and take them back. A lot of these ideas that have been mentioned here--like the water analysis, water chemistry--have been tried. Our laboratory has worked with Fenac as a tool of suppression. By necessity my work has to be of a field nature. I am concerned with large-scale test plots.

Three or four years ago Al Burkhalter was kidding me about hydrilla being in Texas. It had not reached any alarming proportion until recently, when an irate group of citizens came to a Commission meeting and they brought hydrilla with them in gallon jars and gave the Commission a fair sample of it to look at and smell and feel.

The legislature does not meet until January of '79. It does me very little good to repeat to this group that the Commission did say, "Well, you told us so three years ago, but it doesn't relieve our problem."

However, we continue the research with both the liquid and the granulated herbicides in a combined effort to come up with a solution that will give us a maximum amount of benefits for the amount of effort and money that is involved. We have discarded the word "eradication" from our vocabulary. We are looking at long-range sustained management and all these products that are being made available are going to be tested sooner or later.

We will continue to test these products as they become available in compliance with what the EPA says. We will continue all efforts, all means, to incorporate all this new thinking and all this new technology and all these new disciplines that have been mentioned to achieve an integrated program.

Next year I may have to come to the meeting and say, "Well, we

didn't make it, I am back in the class with Florida." Thank you.

PANEL DISCUSSION
BIOLOGICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Moderator - Dr. T. E. Freeman

I have asked the panelists to discuss briefly the status of their work and what they are doing on biological control and more importantly to look toward the future and give us some idea of where they think we should be going in biological control.

As I look back on it over the years, I was a little bit surprised that we were still operating in the same manner, with approximately the same type of agents that we used in the late 1800's when biological control was first begun. That happened to be the case of the scale in California, where they introduced certain pests to control that particular insect. That was the very beginning, about 1888, I believe it was.

It wasn't until some 15 or 20 years later that they went into biological control of weeds. It happened to be with the prickly pear in Australia. Both of these centered around one basic idea, the idea that we are dealing with an introduced species, one without natural enemies. We must therefore go back to the native habitat of that species, look for natural enemies there, and import them into the area. This we are still doing today in many cases.

Most of the early work on biological control was done with insects, very little with any other type. There was a fortuitous incident in the very beginning which may be something that we will be looking forward to in the future.

When they controlled prickly pear in Australia with an insect, it took them several years to find out they had introduced a plant pathogen right along with that insect. They had brought in a bacterial, soft-rotting organism which followed the invasion of the insect into the plant and finished the plant off. That was the early 1900's.

We see evidence today that perhaps that is the way we should go. We need to get a lot of biological controls working, each operative in

a system, each one taking its little toll.

The people at Boris Thompson Institute have estimated that it takes roughly 100 years for an introduced species to come to equilibrium with its environment and its natural enemies and for more natural enemies to come along. We are reaching that 100 years with waterhyacinth, and we may be reaching a point of equilibrium by that time. It is hard for us to conceive of that right now. Certainly, with things like hydrilla we are just beginning a hundred years, so we have a long way to go.

As far as aquatic weeds are concerned, we were very late in applying biological controls to them, but we have been very innovative in this particular field. We have used ducks, geese, snails, shrimp, hippopotamus, manatee, water buffalo, higher plants, fish, insects, and pathogens. That is quite a list of materials. Most of the people on terrestrial weeds have only gotten as far as insects and a little bit of work on plant pathogens, so perhaps we are innovative in the aquatic field, anyhow.

The last four we mentioned are the ones that are probably holding the most promise for us. They are the ones that this panel will represent--the higher plants, through competition, allelopathy; the fish, white amur, which you will have a panel on this afternoon; insects, and plant pathogens.

In our work with plant pathogens we now have one which we feel is nearing the operational stage. That is the fungus Cercospora rodmanii on waterhyacinths.

We have reached the point with this particular fungus where the University of Florida has patented the fungus for use as a weed control agent, and Abbott Laboratories in Chicago has entered into an agreement with the University of Florida to produce it in a product form to sell or distribute for aquatic weed control.

I told them that plant pathogens have many desirable characteristics. One of them is self-perpetuation in the environment, once you establish it there, so their product may have a very short life. It may be a one-time sales item which you don't get to sell a second time.

Perhaps they are willing to take that chance.

That is where we are. This fungus will be used in large-scale tests, one in Louisiana next year in combination with insects. It looks very promising. We hope it will be the one that will buy us a little bit of time to do some more basic work which we need to do.

Not only have we looked at exotic pathogens, ones from the areas in which the aquatic weed is native, we have looked at endemic ones, too. This Cercospora is an endemic one. We can use it immediately in large-scale tests, since it is not an important species. It is safe to use.

We tested it against some 88 species of plants closely related to the waterhyacinth, as well as plants of economic importance. It is highly host-specific to the waterhyacinth and we feel its use would not present any hazard to any other plants. As far as we know, it does not affect animals, fish, humans, cows, dogs, cats, birds, or anything else. So it is an organism which we feel is useful.

As far as exotic pathogens, we have two which look very good. One is a rust disease, which is highly specific to the waterhyacinth, which we found in Argentina. We are working with it in Gainesville. We have applied to have it released from quarantine and have been turned down at the state level and at the federal level. Of course, with the new executive order on the introduction of exotic species, we may never get it out of quarantine. I hope so, but there is a possibility we may not.

We are also working with a Fusarium disease which attacks hydrilla. This is one we imported from Holland. It is a Dutch isolate of the fungus. Fortunately we have domestic isolates of the same fungus, not quite as pathogenic but very nearly so. We are at the stage of having large-scale tank type tests, 10-foot pool tests, with this particular organism, Fusarium roseum, on hydrilla.

We have conducted some more basic studies which are very much needed. We need to find out an awful lot about the interrelationship of these biotic agents.

We were working with a fungus named Acremonium zonatum. It showed great promise we thought, and in certain areas in South Florida and throughout Central and South America, it did quite a bit of damage to

the waterhyacinth plant. At a test in Lake Concordia, I noticed the plots treated with Acremonium zonatum were larger, more robust plants than those not treated, the control.

We put a graduate student to work on that and we found out that certain phenotypic waterhyacinths react to this fungus. It produces indoleacetic acid and actually makes the plant grow faster! Now that is a surprising blow for someone who had high hopes just a couple of years ago for this fungus.

We don't know where we are with it now. We are not going to give up. It has some possibilities for use in conjunction with insects. But it was a blow to us. Actually the material we thought had biocontrol potential actually made certain types of plants grow faster. Other types it did not. We need to know this, and this is where we need to go in the future.

We hope the Cercospora will buy us the time, so to speak, to get something operational. Then we can get into some of these more basic studies which I feel we really need in this particular area.

PANEL DISCUSSION
BIOLOGICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. B. David Perkins

I am going to be talking mainly about integrated control, and of course a basic part of that is the insects which are already out in the field. The work I am going to be mentioning is supported by the Corps of Engineers for the most part. Other supporters of our programs in Fort Lauderdale are the Department of Natural Resources of the State of Florida, the University of Florida, and the South Florida Water Management District.

The results of our studies in integrated control I will mention briefly. Some of our work with fungi has been with Acremonium zonatum, that Ed (Freeman) just mentioned as a growth stimulator. Of course, 2,4-D also stimulates growth, so I can see a potential for further research on that fungus.

We have found that the plant growth is highest in summer, midsummer to late summer. The fungus peaks late in summer and so does the adult weevil population. If one is to apply a herbicide, it would be well to apply it at a time when the plants are beginning to be suppressed by other agents, such as lower temperatures or biological agents in the field, as they occur naturally. This would also allow some of those biological agents to be killed at the same time and not suffer too big a depletion in the number of control agents which are present.

For the control plots which we had in the field, we used a nested type of plot in which we had a plot treated with herbicide. We sampled inside the plot and outside the plot. Then we had control plots also sampled inside and outside the plots.

The units we used are estimators of the quantity of petiole material in each square meter sampled. We determined the average number of petioles per plant, the average number of live petioles per plant, the number of those per square meter, and the length of those petioles, to come up with a figure which would give--if you wanted to think of it in

length of petiole within a square meter--a good estimator of the volume of plant material above the water line.

The treatment in summer dropped the plants to essentially a zero point, where they remained through most of the remainder of the season. Much of this was due largely to the presence of other agents. I mentioned the fungus and the weevils. We also had waterhyacinth mites and the cooling temperatures later in the year, which added further stress. Essentially, our feeling at this point is that the best time to treat, if it had to be done on a basis of once a year, would be in late summer.

We are also looking at the moth, Sameodes albiguttalis. We are attempting to call this the waterhyacinth moth as a common name. This was introduced by the Corps of Engineers two weeks ago with our cooperation and the cooperation of the Florida Department of Natural Resources, and the University of Florida. This population now is one that we are going to be watching closely to determine its effect on waterhyacinth. Thank you.

PANEL DISCUSSION
BIOLOGICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. Leonce Bonnefil

In Puerto Rico, we just recently discovered that we have weeds. We applied to the Corps of Engineers for a complete study of the biological control of the aquatic weeds on the island.

In accordance with the Memorandum of Understanding that the Puerto Rican Department of Natural Resources had, we had to do two things. We had to document the introduction of the white amur and we had also to prepare for the introduction of the hyacinth weevil Neochitina.

The introduction of the white amur was studied and the results are now in the process of being published, probably under the aquatic plant control research program cover. The tests preliminary to the introduction of Neochetina were initiated and are now well under way. Biological control, it is obvious, is to be a very important element in the control of water weeds in Puerto Rico.

It may appear highly improbable that a country so small as Puerto Rico, which measures 100 miles by 30 miles, should have a weed problem of significance. In fact, we do have it, but it is a question of scale. Everything is small down there but is very important.

Our Puerto Rican system of waterways is so different. The streams are very small and short, but they are used for drinking water and for generation of electricity. They also support a growing sport-fishing industry. On the other hand, they are being accused now, whether true or false, of representing a hazard for the transmission of snail-borne bilharzia and the transmission of dengue fever epidemics that we now have. As I have said, this is not yet well documented.

In addition, water weeds in Puerto Rico have been accused of provoking floods in times of high water, in times of rainfall, September to December, and when the water weeds accumulate and form plugs along the waterways. The water weeds of major importance in Puerto Rico are,

not necessarily in order of importance, the waterhyacinth, the alligatorweed, chara, paragrass which many of you may not know, duckweed, filamentous algae, etc.

The island is crossed lengthwise by a rather high mountain which in times of rain causes the waters to rush downhill. In the process of going downhill, they drive down large masses of floating weeds, mostly waterhyacinth. These waterhyacinth die on contact with the ocean water, so that is a very good natural control. We took advantage of that many times when we developed programs of water weed eradication.

We don't yet know what is going to be the importance of the different methods and strategies. In the new program, hopefully, large emphasis will be given to mechanical removal, to chemical control, and also, at a later date, probably biological control.

The bilogical control we will limit to a certain area where it is not practical to bring in any machinery for mechanical removal or to spray. We have quite a few of those areas. We are counting on biological control as a support for both mechanical and chemical control.

It is probable that the waterhyacinth weevil, which will be liberated shortly, will assist us. Our streams are sinuous, and there are spots where the weeds concentrate. Also, in the lakes and reservoirs we have fingers and these are the places where the weeds develop and breed.

After we have introduced the waterhyacinth weevil, we will consider the introduction of Agasicles, the flea beetle. Because our streams are short and rather shallow, there is generally limited chance for the dilution of herbicide residues and this is a great problem.

Our local EQB, Environmental Quality Board, is aware of this and is requesting that our spraying operations be monitored so that the specified levels of tolerance are not violated. They have, by the way, a limit of tolerance that is lower, 0.08, as compared to 0.010 of EPA. According to EQB, we should do our spraying only in conditions where there is a good chance for dilution and mixing of the water. This will coincide with the period of the year when the weeds will be concentrating, which is very good.

For a number of years 2,4-D has been used in the main watersheds of Puerto Rico but, fortunately or unforunately, on a very small scale and without any continuity. It has been done largely by the aqueducts and sewer authority. They have made some analysis to discover that only traces of 2,4-D were to be found in the drinking water that goes to San Juan.

Last year with the valuable assistance of the Corps of Engineers, we made a large-scale application of 2,4-D in one of our major streams called LaPlata. Understand that what we call "large-scale" application in Puerto Rico is probably five miles over a body of water, but that for us is very big.

In spite of all the fear that was expressed by both our officials and by private individuals and groups, at least no immediate ill effects were recorded on animals, on plants, on humans, or on cattle. We are still administering and we are not finding any really adverse effects.

They accused us then of building up an excessive amount of organic matter, but that accusation was dismissed when we pointed out that along the waterway there were several dairies that were producing effluents and also there was at least one water purification plant. So we are not at all depleting the oxygen. We have, ever since, been constantly monitoring the water. If we come to large-scale operational spraying of pesticide, we will have to do it on a regular basis.

The real problem is that any large-scale application of herbicide should be normally followed by maintenance, and this we don't have. In some of the treated areas, we find that the dead waterhyacinths become completely overgrown in five to seven months.

Another of the problems that we have been faced with is that the waterhyacinth is tied down by paragrass, a bank vegetation that will grow over waterhyacinth. As it grows over the waterhyacinth it sends stolens down that anchor to the bottom so that it takes great force, even a machete, to separate it and let it go downstream.

You see that it is not easy under these conditions to be thinking of any strategy in particular. It has to be a mixture of practically

everything, and we plan to do just that. Whenever it is possible, we use one method, but another situation will be different.

We are now in the process of restoring the flow in the LaPlata River, using all the means that we have at our disposal. To do that we have created an interagency committee, where all the government agencies that have to do with water contribute machines. It is working quite well so far.

Concurrently with EQB, we are emphasizing better disposal of the effluents from the dairies and a better treatment of the waste waters. When we release our insects, we hope that it will lessen our problem and make it easier for us to solve our very crucial problem in certain areas.

The problem that will remain, however, will be the problem of the lakes and reservoirs, especially those where the water is used for drinking. There we have to use herbicide, but already we know that we will not do any spraying without having it very closely monitored. We will be doing it only when we have proper conditions to do it. We have been concerned lately with the thermal stratification that occurs in Puerto Rican waters only in certain months. The mixing of the water masses is very desirable, and we will be concentrating our efforts on those periods.

Also, the BOD (biochemical oxygen demand), the dissolved oxygen, and the nutrients will be periodically measured to make sure that we are within normal range. Should there be an excessive disturbance in any one of these parameters, we will promptly attend to its change; we will apply appropriate corrective measures. Now that we have all the agencies grouped into one committee it will be easier to have one unified action. That way we think we can solve the problem, and everybody, including the defenders of the environment, will be happy because right now they think we are doing something that really shouldn't be done.

That will be all. Thank you.

PANEL DISCUSSION
BIOLOGICAL CONTROL TECHNOLOGY DEVELOPMENT

by

E. E. Addor

In the absence of Dr. Ted Center, who has done work concerning the Arzama, I would like to explain that anything I say about Arzama can be attributed ultimately to his work.

My purpose is to stimulate questions or discussion on the environmental and physiological constraints on the population densities and distributions of these organisms.

Those of you who attended the planning conference last October will perhaps recall that at that meeting I reported on a small-scale controlled plot experiment on Lake Concordia, which was intended to test whether selected insects and pathogens could be used in combination to induce a controlling epiphytotic on waterhyacinth and, if so, then which combination would be most efficient.

You will recall that as a result of that experiment it was concluded that some mixture of organisms, obviously including the test organisms, but not necessarily restricted to those, was effective against waterhyacinth in the environment of Lake Concordia. It was not obvious, however, which organisms were the necessary and sufficient combination.

I now report that observations on those plots have continued to date, and in addition, a test series has been initiated on a larger scale on selected field sites widely distributed across southern Louisiana. So far, tentative introductions of selected organisms have been made on some of those field sites.

More important for our present purpose, the sites have been examined critically for plant condition and for presence of various naturalized insects and pathogens at approximately one-month intervals since the beginning of the current growing season. I emphasize "naturalized."

I now offer some highly subjective impressions based on these observations of the population behavior and interactions of the species

that were used in the Lake Concordia plots and of certain other native or naturalized organisms.

As Dr. Freeman mentioned, Acremonium zonatum was used on Concordia. It is a fungus, native or naturalized in the U. S. and widely but sporadically distributed. Apparently it is specific to waterhyacinth, and it was chosen for the Concordia tests on the basis of documented potential virulence. On the Lake Concordia plots it readily became established after the initial application, but then it diminished toward the end of the first season. I have not seen it anywhere on the lake since that season, which was in 1975.

I have found it on two or three of my Louisiana field sites, but only on rather tall congested plant populations. On those sites it has not shown evidence of virulent pathogenicity.

It appears to be quite sensitive to environmental conditions, especially temperature and humidity. Martyn has recently shown that it may be responsive to the concentrations of phenols in the hyacinth leaf and hence to plant vigor. He indicated in fact that it improves the vigor of the plant.

Cercospora rodmanii was discovered in cultures derived from spores collected at Rodman Reservoir in Florida in 1973. When originally collected, those spores were thought to be Cercospora piaropi, a species known in the U. S. since 1917 but not previously known to be seriously pathogenic.

The isolate now defined as Cercospora rodmanii, however, appears to have the potential for extreme virulence under natural conditions. It has not been determined whether this fungus alone will devastate a waterhyacinth population, though the evidence strongly suggests that it will do so, at least under some circumstances.

My question regarding that species is, where did it come from, where has it been all these years.

Arzama densa is a moth. It is native or naturalized in the U. S. and apparently specific to plants of the Pontederiaceae, which includes the waterhyacinth and pickerel weed. Its distribution is apparently sporadic, and it is abundant only occasionally in local outbreaks. When

it is abundant it inflicts massive but localized destruction on a waterhyacinth population.

It is not known whether the plants are then predisposed to serious attack by other organisms or how readily they will recover from this destruction. It appears that _Arzama_ attacks only the most vigorous plants, and dense populations of the insect apparently cannot easily be established or artificially maintained in the field.

Neochetina eichhorniae is a weevil, introduced from South America in the early 70's. By now it is already widespread in Louisiana as a result of deliberate spreading by the Louisiana Fisheries and Wildlife Commission. Viable populations are quite easily established, even with relatively few insects, but the dynamics of established populations is enigmatic. In some places the populations have become very dense within a few years, while in other places they remain quite sparse.

In my observations so far, I find populations of the greatest densities and of the most rapid buildup on plant populations of intermediate vigor, while on very lush plant populations the _Neochetina_ populations persist but at very low densities. They will persist on plants of relatively low vigor when other plants are not available, but apparently they will not establish dense populations on plants of very low vigor.

By itself _Neochetina_ does not appear to be capable of devastating a waterhyacinth population, even at very high insect population densities. Perhaps that observation may conflict with something Dr. Perkins has seen in Florida.

On the Lake Concordia test plots, _Orthogalumna terebrantis_, the waterhyacinth mite, became established during the first year and was associated exclusively and consistently with _Neochetina_ during that year, which lent some credence to the suggestion that a commensal relationship exists between these two organisms.

It was supposed at that time that _Orthogalumna_ was inadvertently introduced to the test plots with _Neochetina_. My subsequent observations deny that hypothesis. _Orthogalumna_ is ubiquitous on waterhyacinth in Louisiana and there is reason to believe that it is best adapted to plants of intermediate or relatively low vigor. The buildup of its

population with Neochetina would thus seem to be opportunistic. Neither is it certain that an intense infestation of Orthogalumna will stress a waterhyacinth plant beyond the stresses imposed by other causes.

On the basis of observations so far, I suggest that Orthogalumna occupies that portion of a leaf that is rendered physiologically inefficient by other stresses and in that sense it is either irrelevant or perhaps even beneficial to the plant.

Finally, there is some evidence that other waterborne microorganisms not considered in these tests, and which I have not observed in my more recent field observations, may have contributed significantly to the epiphytotic on Lake Concordia. These would include viruses, bacteria, and in particular nematodes, which may invade the plant tissues through wounds left in the lower petiole when the Neochetina larvae emerge to pupate. That may be the significance in Neochetina, but I am not sure.

PANEL DISCUSSION
BIOLOGICAL CONTROL TECHNOLOGY DEVELOPMENT

by

James Manning

We have possibly got another biological control agent in the state, that occurs naturally, that might prove beneficial in years to come. We have a lot of trouble with local commercial crawfishermen in the Atchafalaya Basin during crawfish season. They don't want our crews spraying waterhyacinth because of the beneficial aspects they see from the crawfish feeding on the waterhyacinth roots.

We have inspected huge mats of waterhyacinth and have found severe feeding on the root system. Considering we had a pretty good year for crawfish several years ago--and I think we have reached over 1.7 million acres of waterhyacinth in the state, several hundred thousand of them in the Atchafalaya Basin--I don't think it would work out.

We have several management things going on in respect to waterhyacinth. Agasicles has been highly successful in our program on alligatorweed. The only parts of the state where it hasn't proved beneficial were in isolated areas, mainly in northeast Louisiana where a lot of cotton spraying is going on.

In southern Louisiana, though, they have literally wiped out the floating mats of alligatorweed, although we have noted that there is a little bit coming back. We have noticed several areas that do have Agasicles in them, so we expect the beetle to come back with no problem.

We started our biological control in, I believe, 1974, when we got 113 adult Neochetina eichhorniae from the Corps of Engineers. We built a greenhouse in Baton Rouge for these weevils. After a very few weeks we found out that there was no way to utilize a small greenhouse to get a large number for field release. So we started thinking along the lines of setting up some field nursery areas. Around July of '74 we moved into the field with several releases of adult Neochetina.

In July '74 we also acquired 100 bruchi eggs from Neil Spencer in Gainesville. We carried these back to Baton Rouge, and hatched and

transplanted about 55. We put these in another greenhouse we had set up. Ultimately, in '76 we went out to the field with these, although we had a few minor difficulties in getting a large enough population.

In '75 we were checking our nursery areas for spreading of the insects and really weren't too impressed.

Adjacent to this one nursery area was a swamp which extended 20 or 25 air miles, full of waterhyacinths. We started planning and decided we couldn't put these bugs out in the bayous. So we got our airboats and started physically putting these things back in the swamps. Everywhere we went we would start to put out some bugs and grab a waterhyacinth and look, and we would find feeding spots on them.

In a year and a half those things, out of an initial 100 released at that site, had traveled approximately 15 miles through the swamp, and across a couple of states and rivers. As a result of this, we have had approximately 40,000 acres of waterhyacinths in that swamp that have not flowered this year. We are not saying the bug is killing the waterhyacinth, but it is doing what we feel is very beneficial to us, stopping the flowering. That means less plants we will have to worry about in the future from seed germination.

We put these bugs out all over the state last year, but this last winter was very severe and I think we have lost all. In the north Louisiana locations, I am not saying the freeze did it. It killed the waterhyacinths, and I believe we lost out weevil populations from that. I have heard no reports of surviving weevil populations there. South Louisiana fared a lot better. Week before last, I think, I released, 10,000.

We got away from this airboat business because it was too slow. For the last year and a half we have had a contract for a Bell jet ranger for spraying 2,4-D in our normal spray program, so we just kind of moved in with a helicopter.

They don't like it too much, but we have crews pick our bugs. We are using about a 12-ounce Coke cup, biodegradable of course, with a plastic top. We have moved up to using about 400 adult weevils to the cup and put a few waterhyacinth stems in it, cap it, possibly keep it overnight, depending on when I get them. We leave with the helicopter

early in the morning and we make our releases.

To date we have released 63,100 adult Neochetina eichhorniae in 286 locations in the State of Louisiana. We have only had four release sites with the bruchi, totaling, I believe, 1052 adult bruchi.

Now for our plans for the future. We have noticed this year, especially in the very dense populations, that the eichhorniae are moving out of the severely fed-upon plants to newer plants. One reason they are moving, I think, is that they can't find any more places to feed on the leaves. They are just eaten alive and the plants are still standing. I think I have read some reports that bruchi possibly will stay on that plant a little longer. We are planning on pushing our bruchi release into some of these areas that we have stocked with eichhorniae. We plan to continue using the helicopter.

I would like to see some more work done on this new moth. We are going to check with Dr. Perkins and get a state label or state release on it and go with it, too. Thank you.

PANEL DISCUSSION
BIOLOGICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. Peter Frank

I was asked to talk about biological control work at Davis, but with the time limitation I think I will restrict myself principally to our studies with the spikerush as a means of biological control of aquatic weeds, at least in the western areas.

The two species of spikerush that we are primarily interested in are _Eleocharis acicularis_ and _Eleocharis coloradoensis_. We prefer the _coloradoensis_ because it is considerably smaller than _acicularis_. I understand _acicularis_ is considered to be a weedy species in some areas. However, we would prefer the weed problems that arise from _acicularsis_ to some of the problems that we have from other types of weeds at the present time.

The competitive effects of spikerush on other aquatic weeds was recognized and reported by an ARS employee in Denver back in the 40's. Unfortunately, his work was buried in an obscure laboratory report and really only came to light recently as a consequence of my personal knowledge of the report.

In the late 1960's the effect of spikerush on other aquatic plants was observed by a number of people in California. For the next half a dozen years or so, work on spikerush was limited primarily to a few test plantings and field observations.

We believe that the principle involved in the competitive nature of spikerush was not restricted to any competition for nutrients or for space or whatever. To us it appeared to be more of an ideal case of allelopathy, which is the effect of a chemical produced by one plant on various life processes of other plants.

During the past two and a half or three years we studied spikerush from the angle of allelopathy. We believe that recently we have demonstrated quite conclusively that allelopathy is strongly involved in the phenomenon.

At the present time our work with spikerush involves fairly large-scale field plantings in canal sites and lake sites. It is too early yet to give you any report on success or failure.

In addition, we are doing some work on physiology of the plant, ecology of the plant, and we are now entering our third year of a three-year study on the edaphic factors that control or influence the establishment and distribution of the plant.

We don't believe that spikerush is for everyone or is a solution to every aquatic problem. In fact, from what we know of the plant, from what we have observed, we know that it isn't. There are only specific sites where it will become established and will work effectively. But we feel that if we can get spikerush to work effectively in as little as 10 percent of the aquatic sites in the western states where we now have problems, we feel we have a sure winner.

I would like to mention that we have a number of PL-480 research programs in foreign countries that deal with aquatic weed control. We have one in India that was just recently negotiated. We have two in Pakistan, one involving aquatic weed control, biological control, primarily with fishes, including the white amur. By the way, in respect to white amur, we don't want any in California because it does like spikerush and it will eat great amounts of it.

The other PL-480 project I would like to mention is one that we have involving control of waterhyacinth with a pathogen, an Alternaria organism. That is a five-year project that has been in existence for slightly over a year. I feel reasonably confident that we are going to get some interesting data from that project.

PANEL DISCUSSION
BIOLOGICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Leon Bates

I would like to talk briefly with you about two aspects of plant competition. One, of course, is the aspect that Pete Frank just mentioned to you, dealing with spikerush. The other aspect deals with a vegetation management or manipulation scheme that we have had underway for a few years in TVA.

For those of you not familiar with Eleocharis acicularis, it is very similar in appearance to Eleocharis coloradoensis that is found on the West Coast.

It has a very dense rhizomatous growth almost like grass sod. This I think is one of the factors, too, that helps the species exert the allelopathic reaction to other species. Even when the substrate is washed off, it still clings together and makes a good shade.

We do not have problems with this slender spikerush in the valley. In fact, it is considered to be a desirable species. Our fisheries people consider it to be a very ideal spawning medium for some of the fish.

One of the first reservoirs in which we noticed this allelopathic type reaction was a small reservoir in upper East Tennessee that was infested with Potamogeton crispus, the curlyleaf pondweed. We noticed in the stands of Eleocharis that the crispyleaf pondweed did not grow in association with this.

We also were able to find out in this one experiment that some of the 2,4-D formulations, particularly the butoxyethanol ester, and also two of the Endothall formulations, did not significantly reduce the slender spikerush while they were very effective on the surrounding crispyleaf pondweed.

The other aspect of this study of vegetation manipulation, particularly as it relates to TVA studies, is the use of water-tolerant tree plantations in some of these upper reservoir fluctuation zones, particularly those zones that have high densities of emergent vegetation. We

have two series of experiments that have been conducted in TVA.

The older experiment is about 40 years old. These initial experiments were designed to offer a means of controlling the herbaceous vegetation that of course harbored and bred the Anopheles mosquito. Some of these older plantings had several variations in spacing. They went all the way from a four-by-four up to an eight-by-eight spacing.

In these artificial plantations, of course, we were able to control the stand density and therefore manipulate the shading effect. This is in contrast to some of the natural stands where we have very irregular spacing and irregular numbers of stems per acre.

Those of you here, of course, are involved with other aspects of reservoir management. You have interchange and cooperative work with the fisheries people involved. You have people in your recreational area that you cooperate with, and this is an aspect of vegetation management that fits in with some of these other uses of reservoirs.

The tree plantations at least have great potential for aesthetic enhancement, particularly in recreation areas where emergent vegetation may be a problem. I think tree plantations are amenable to controlling emergent vegetation and at the same time providing aesthetically desirable groves of trees. Of course, in some situations these trees could be harvestable at some date, getting an economic return as well.

The mosquito control aspects I have mentioned. In general, if you can control the herbaceous species, you can control the mosquitoes or a certain species complex of mosquitoes. In some cases you can turn the species complex around so that the mosquitoes that you do have are those that stay in the tree plantation. You actually have to go inside the plantation to get bitten.

We have looked at several tree species. The one that we have looked at most is the bald cypress, *Taxodium distichum*. They are very tolerant to planting, even as deep as two feet down into the water as seedlings. Other species that we have looked at to a limited extent include white cedar, *Chamaecyparis thyoides*, various bottomland hardwood species, sweet gum, and sycamore.

Certainly more research needs to be conducted in this field of

managing aquatic weeds by beneficial aquatic plants. The wetland macrophytes I think can be exploited. We need to look at the positive aspects of some of the native species that we have, and even perhaps some exotic species that are amenable to these programs, and apply them to the integrated management of some of the reservoir systems. Some of these perhaps are impractical, but I think some of the others have very possible application in specific locations on reservoirs and even irrigation systems.

For those of you who receive the Journal of Aquatic Botany, there is an interesting article in the last issue that deals with the use of plantations along irrigation systems to shade the submersed species in the canals and actually to indirectly operate as a controlling influence. Various aspects of this might be considered, such as a tree canopy with, say, a shade tolerant under-story shrub community that would give more dense shading.

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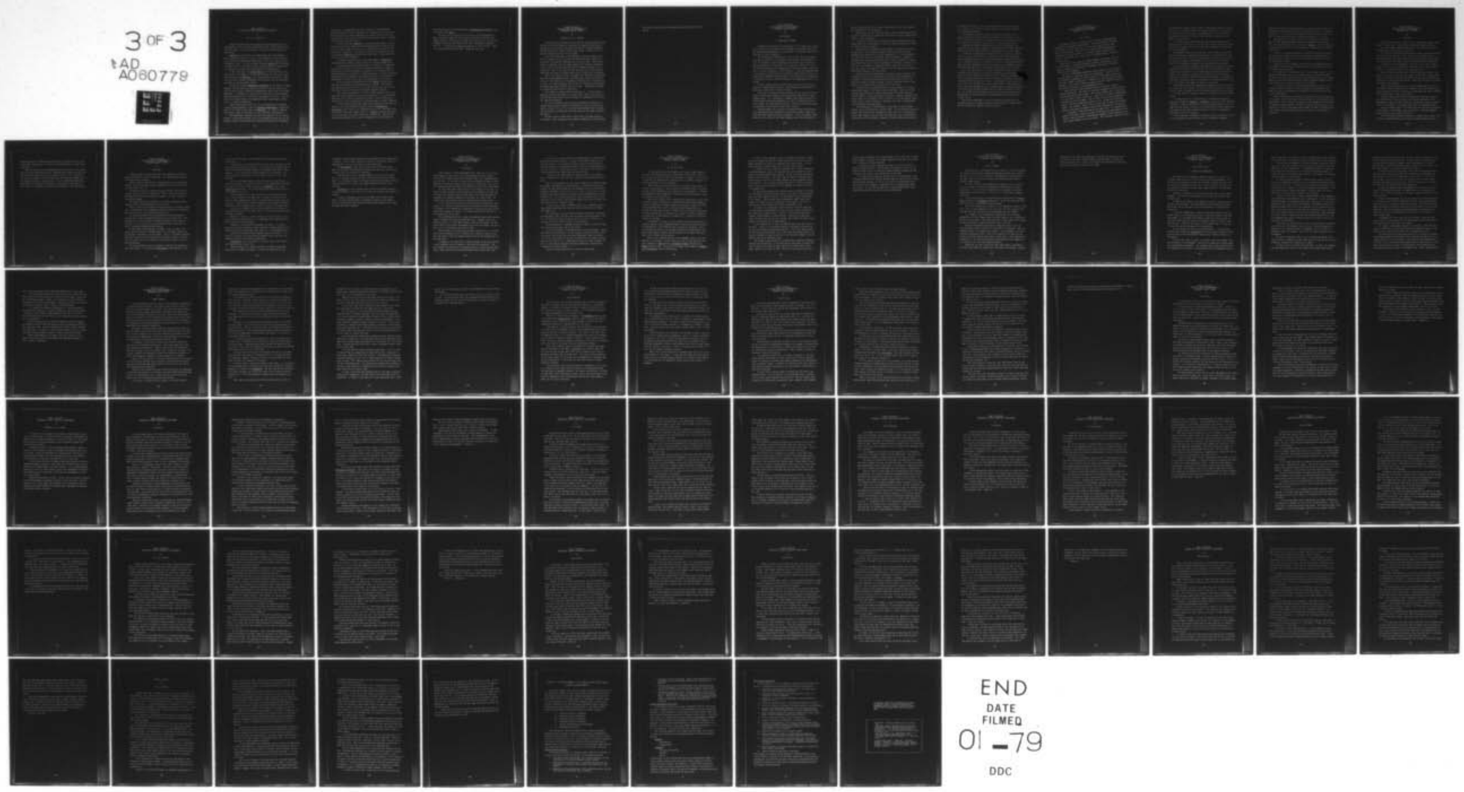

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PANEL DISCUSSION
BIOLOGICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. P. C. Quimby, Jr.

George Vogt and I have been engaged in monitoring biocontrol of alligatorweed in the lower Mississippi Valley and eastern Texas for the past five years. We have been greatly assisted by Bill Thompson and Clyde Gates.

Agasicles is favored by cool, damp weather and high humidity. When we have had periods of fog, a lot of humidity, we have even found it on the beach, reproducing, laying eggs, in all life stages, and in terrestrial sites. For the most part, however, Agasicles is restricted to aquatic sites on the edges of mats of alligatorweed of shorter stature, because it requires this high humidity for reproduction.

On the other hand, the Vogtia malloi, or stem borer moth, is favored by hot, dry summers as we have had the past two years and is more cold resistant than Agasicles, as we witnessed this past winter. Both of these insects depend on migration from southern latitudes northward each year in the Mississippi Valley.

We have not observed Amynothrips andersonii in our region of study. However, we have found three species of native thrips and over 60 species of native insects affecting alligatorweed, some of which are rather important. For example, the spinach flea beetle will attack alligatorweed in terrestrial sites only because of pupates in the soil. This insect will decimate stands of alligatorweed along canal banks, however, it is of limited distribution.

George (Vogt) would still like to try introducing one remaining insect from South America. That is Disonycha argentinesis, a close relative of the spinach flea beetle and Agasicles. It, like the spinach flea beetle, would be restricted to the terrestrial alligatorweed.

The replacement vegetation has been very important in the overall picture. We now have recorded over 100 replacement species and over 30 species invading floating mats and forming what George calls embalsados,

which prior to alligatorweed has never occurred in North America. George believes that these embalsados are important because if they remain persistent as complex communities of several species, then they could result in obstruction of navigation and possibly create a problem that has never been here before.

We have found that Agasicles is limited by many things. We have released them several times in the Mississippi Delta and failed every time. The main thing that seems to be involved there is drift of insecticides, toxaphenes. Joe Kresge in our lab has looked at the toxicology against Agasicles and found that this beetle is very sensitive to very low doses of toxaphene.

We became interested also in what might happen to Agasicles if alligatorweed were taking up heavy metals in certain polluted sites.

Growing alligatorweed hydroponically in solutions of cadmium at one part per million, we got about a sevenfold increase in cadmium in the plants, 140 percent increase in mortality on the adults, and 100 percent reduction in fecundity, no eggs laid at all. So this shows that alligatorweed can accumulate toxic metals and that this can result in plant-insect interaction that would be detrimental to the insects.

We are working on developing a diet for Vogtia, the moth, and have had very limited success and may never succeed. These insects were introduced because of their host plant specificity, and diets are very hard to come by for some of these host-specific insects.

Where do we go from here? I think I should mention that Dr. Len Walker has been assigned to our unit at Stoneville. He is a plant pathologist, and he will be working on diseases of water primrose in a joint project with the University of Arkansas with Dr. George Templeton.

As far as other plants that might be considered for biocontrol efforts, we are very interested in parrot feather, Myriophyllum brasiliense, which seems to be increasing in our area. We would be interested in some other comments about it. Egeria is another possibility for cooperative work with our ARS lab in Argentina. That lab has been funded primarily by the Corps of Engineers, too, but there are

some possibilities for increased work on Myriophyllum brasiliense, parrot feather, and Egeria.

We would like to continue the monitoring of alligatorweed and make a plea for support for work of this type after a problem is no longer economic. You know, 2,4-D came out in the 1940's. We have been studying 2,4-D ever since and we still don't understand everything about it. I would say the same thing applies to these insects. There is a great deal that we can learn. Thank you very much.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Moderator - R. F. Theriot

We have broken this panel into two distinct groups, mainly for discussion of the Lake Conway test and then for general considerations. The panel you see now are the contractors who will address themselves specifically to the contract work on Lake Conway. Then we will go to general considerations for the white amur.

As has been mentioned, it was decided to drop the losers and go with the winners, one of the potential winners that was looked at as biocontrol for submersed vegetation was the white amur. There were a couple of questions that we thought needed to be answered, especially for the scale of control that the Corps of Engineers needed for its reservoirs. Most of the work that had been done in the past with the white amur was done on a smaller type scale, in small pond situations.

Some of the questions that we thought still needed to be addressed were of an environmental nature, concerning both direct and indirect effects of the white amur in an aquatic situation over a longer period of time. So, when the project was started, we looked for a system that was larger than what had been used in the past. Originally we looked for something between 1000 to 5000 acres.

Lake Conway in Orange County was settled on. It had a history of hydrilla problems going back to, I think, 1963. Most of the control that had been done before the introduction or commencement of this project was with chemicals.

We tried to develop a data collection program as complete as we thought was necessary to answer the questions of both the direct and indirect effects of the fish. We pooled the knowledge from the people who had worked in Florida and with other agencies for these scientific parameters.

We came up with a whole host of biota that we thought needed to be studied. These contractors will address themselves to the data that

have been collected in the last year, which was our baseline data period.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Don Blancher

A. LAKE CONWAY PROJECT

Yesterday the question was asked whether or not anyone was looking at the impact of these weed control programs on the aquatic biota and the water-quality parameters, in other words, the indirect effects that they have on these parameters.

When large-scale efforts such as this one are started, consideration must be given to all variables in the system. This approach, a sort of integrated ecosystem approach, was foremost in the minds of those people who first conceived of this project. Efforts to look at the entire system, all the components, not just weed biomass, are necessary if a full evaluation is to be effected. It was the responsibility of our group at the University of Florida to gather baseline data and establish the abundance and diversity of the microbiota and benthos and to determine the basic nutrient loading for nitrogen-phosphorus for the system.

The Lake Conway system is located directly south of the City of Orlando in Orange County, Florida. The 739-hectare lake consists of five pools connected by a series of canals.

From north to south, the pools are Lake Gatlin, the west and east pools of Little Lake Conway, and the middle and south pools of Lake Conway proper. It is important to remember these lakes because as we discuss some of the other parameters, we will be talking about east, west, middle, and south pools and Gatlin. Water flow from these pools is generally in the direction from north to south.

Plankton samples are collected on a monthly basis from each pool. Both phytoplankton and zooplankton collections are made, along with other pertinent physical-chemical parameters. Since the benthos components are less likely to have rapid changes, these are collected at a

little longer period of time, every other month for the invertebrates and quarterly for the periphyton.

Additionally, we are collecting data to determine hydrological and nutrient flux through the system for construction of basic input-output models of these components.

I am going to start with a discussion of the preliminary nutrient budgets which we have developed to date, and Roger (Conley) will follow me, talking about the biota.

Most important in determining the impact of the white amur on the total system is the internal cycling of nutrients within the lake. Exchange rates between the different components, i.e. the macrophytes, the fish, the plankton, the benthos, and the sediments, in general determine the basic characteristics that a lake will exhibit, by which we perceive the lake as being oligotrophic or eutrophic. However, before you can know what is happening within a lake, you first have to get some idea of the amount of materials that are entering the lake and where these materials are coming from.

Although we have obtained data on internal nutrient cycling, this information has not been completely collated for this presentation. I am going to briefly go over our nutrient loading model, that is the external loading, and what it means or how it expresses itself in the lake, i.e. in water quality and the rest of the biota.

To begin with, any nutrient budget is only as good as its basic hydrological budget. The model we have developed to date for the system has some difficulties simply because most of the data have been obtained during a fairly dry year in that area. However, looking at the model itself, or the budget itself, we believe it is essentially correct within plus or minus 10 percent. Basically, the lake is predominated by precipitation and evaporation.

By determining the concentration of nutrients in the incoming waters, we can then develop a nutrient model. In the nitrogen and phosphorus model that we have developed to date, there are a few question marks, some things we are actively investigating, such as denitrofication and some of the sediment leaching, nitrogen fixation and nutrient

recycling in the lake. These parameters haven't been fully explored yet. However, the external loading characters are basically correct and essentially complete.

Precipitation, airborne combined dry and wet fallout, is the largest contributor of nitrogen and phosphorus to the system. These are all expressed in loadings and grams per meter square of lake surface area, which is an invention usually used in these loading models.

Although the airborne components are the most important, other components such as urban stormwater and seepage into the lake, although smaller, are still very important in determining the nutrient budget.

A model was developed by Volenwyder in 1975, in which the trophic state of a lake can be related or predicted by its total phosphorus loading characteristics and the lake's hydrological flushing characteristics. Phosphorus loading is expressed in terms of lake surface area in grams per meter square per year on the abscissa, and flushing is represented by mean lake depth, Z-bar and residence time plus W of water.

Four lines are drawn to represent the empirical limits that are predicted by the model for critical and permissible loading rates. Above the lines a lake would be expected to be eutrophic and below the lines the lake would be oligotrophic. Basically the Conway system would be expected from this model to exhibit a mesotrophic condition, as the total model for the basin falls right in the center. When looking at each of the pools separately, and a separate model is developed for each of the pools, we see that generally as one moves from south to north, that is, through the south, middle, east, and west pools and then into Lake Gatlin, we see an increase in eutrophication or an increase in trophic state.

This will be important in the future because assuming that the external loading will remain constant, future changes in trophic state may be attributed to internal nutrient cycling.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Roger Conley

The elements that we are studying are periphyton, phytoplankton, zooplankton, and benthic invertebrates. We have essentially a system of a little less than 2000 acres in five pools, which tend to work rather independently. However, due to similarities in geography, in urbanization around the shores, in climate, and the free access of species flow between pools, they tend to be rather similar, some more so than others.

Basically we take about 40 samples monthly on plankton in 20 different locations, bi-monthly samples in benthic invertebrates, also about 40 samples in 20 stations on plankton, and about six stations quarterly for periphyton.

Among the predominant periphyton species present in the lake are a large number of important species of blue-greens. There are very, very diverse assemblages of greens and quite a few diatoms, which are also very common in periphyton. Periphyton, by the way, are the algae growing, in this case, attached to plants, the most important substrate, but can grow attached to any submerged material.

Glass slides are very commonly used as a substrate in water-quality monitoring. Two racks of slides are suspended in each location, at one meter and at the surface. The surface samples don't really give us a good idea of what is going on. They tend to be very low abundances, especially during the summer. Most of this is due to high temperature stress. The water temperature gets up to 31, 32 degrees, especially right at the surface. There is also a great deal of wave action, which tends to wash away the material which would accumulate at the surface.

Chlorophyll values show exactly the same trend. We compared abundance of periphyton taken on natural substrates, the macrophytes at each station, and all species of macrophytes sampled at each individual station lumped together for all the pools. The difference between this and

the abundances sampled on glass slides is that peak abundance occurs in the fall set of samples rather than during the summer. The difference is that nutrients are available to periphyton due to the die-back of macrophytes in the fall. There is some nutrient leaching from the plants during the fall.

It is very obvious that there are very large accumulations of benthic algae in the fall, so it is not just a matter of nutrient availability in the water, but it is an interaction between the periphyton and the macrophytes.

Phytoplankton exhibits the same basic trend, which is very, very diverse assemblage of plankton, large numbers of blue-greens that are important, but very, very diverse assemblages of greens, none of which are terribly important individually, a few diatoms, and only three species of cryptophytes, important only during the winter months.

A major taxonomic breakdown shows approximately equivalent numbers of greens and blue-greens with periodic blooms of blue-greens, especially this last summer; in June and August, especially, we had large numbers of blue-greens. Diatoms tend to peak in the early spring, getting up to about 20 percent of the material sampled. Cryptophytes, some small flagellated forms, are important only during the winter, but up to 50 percent of the algae is present at that time.

Zooplankton now--rather depauperate zooplankton in terms of northern lakes, but about average for lakes in central Florida. In terms of overall biomass, copepods are the predominant organism during the year.

The same types of seasonal trends are evident, with a late summer crash.

We think that this is associated with invertebrate predation, predation probably by Chaoborus. Chaoborus is associated with eutrophic conditions. This has been a year of more eutrophic conditions in the lake than last year, in terms of the species present, which seems to be the reason for the rather large difference in terms of zooplankton abundance in most of the pools.

We have abundant information available on all of the pools in each of the components studied, whether these be indicator organisms,

traditional indicators of water quality, or organisms which prove to be important in terms of food regimes for invertebrates or for vertebrate predators. It is this kind of information which may become very important in terms of what we learn following introduction of the fish.

Large numbers of different species of invetebrates are present. By far, the most important groups are the chironomids and oligochaetes. The other group basically is the species of Diptera. There are approximately equivalent numbers of each throughout the year, with no significant trends.

In most of our sampling we make a fundamental distinction between the littoral zone stations, that is, the stations around the shore of the lake in water that is less than three meters in depth, and those in the deep-water stations.

Unlike most of the plankton, which tends to peak sometime during the spring or summer, benthic invertebrates tend to peak much later in the year with cooler water.

The reason for the precipitous drop in late summer in most of the benthic invertebrates is due to a slight thermal stratification that develops in the lake, with associated lower oxygen present in the deeper water and with high temperature and therefore decreased oxygen availability, and also to insect emergence in the spring.

In every case, because of oxygen availability and because of the presence of plants, both in terms of abundance and diversity, many, many more benthic invertebrates are present in the littoral zone than in the deeper water.

What we have then are 18 months of baseline data on the microbiota of the lake, all of which seem to indicate that the lake is essentially mesotrophic. There are no particularly unusual characteristics in terms of lakes in central Florida. We think the data we have are going to be sufficient to detect even small-scale changes in terms of trophic structures within the lake which may occur as a result of introduction of the fish.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Roy Land

Our end of the contract calls for a fish population study on Lake Conway. I would like to run briefly through our sampling methods.

We use a blocknet, Wegener ring, 20-foot and 10-foot seine with electrofishing, and we also run gill nets.

For some of you who may not know what a blocknet Rotenone treatment is--we put out an acre net, we go in and put in Rotenone, which is a vasco-constricter that causes the fish to come up, and we pick up these fish for the next three days, weighing and measuring each individual.

Gill nets are self-explanatory. They are put out for a 12-hour period. The fish try to swim through and their gills become caught in the mesh. We weigh and measure each individual fish.

Wegener rings are usually used in heavily vegetated areas. Basically it is a float at the top, mesh down the side, with a strap steel bottom. You go out and throw these Wegener rings, you put Rotenone inside, and you pick up the small fishes. Again, all the fish are weighed and measured individually.

Some of the more common fish on the Lake Conway species list are the coastal shiners, chain pickerel, Seminole killifish, bluefin killifish, bluespotted sunfish, very much so, along with your sport fisheries of large-mouth bass, redear, and sunfish.

By electrofishing the beach we obtained more individual species and individual fish than with any other sampling technique we use. A mathematical formula has been worked out on species evenness that pertains to the number of individuals taken with each sampling method.

Species richness--this is a formula that has been worked out based on the number of individuals taken per species. The Shannon-Weaver diversity index shows species diversity.

We have one other sampling technique, a random creel survey. This is where an employee goes out and stops individual anglers, and he

obtains pertinent information such as what he is fishing for, how long he has been fishing, etc. All this is recorded and sent to North Carolina State.

From the results of our year-and-a-half creel survey, it was found that the species-directed value for largemouth bass ranges from 0.9 fish per hour in the summer of '76 to a high of point 0.35 in the spring of '77, with an average of 0.24 fish per hour. The national average is 0.2 for largemouth bass, so Conway has got a fairly stable largemouth bass population. The average for bluegill is 0.98 fish per hour, which in most circles is considered a fish per hour catchable, a good population.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Larry Nall

Biomass studies on large lakes have been uncommon in the past, mostly because of a lack of methodology. Our sampling apparatus was designed by Carver Aquatics.

Before, percent cover has been the parameter used for vegetation studies. Now we can sample biomass rapidly and we don't have to get into the water to do it.

The sampling device is lowered through the water, and revolving cutting teeth cut a core of vegetation. When it gets to the bottom, pie-shaped doors close and contain the sample. It takes a quarter-meter square sample.

The vegetation data we obtained for the lake corresponds almost exactly with the six-meter-deep line in the lake.

About 37 percent of the lake is below the five- to six-meter interval. As determined by the fathometer, about 42 percent is unvegetated, which is very close to the area below six meters.

For South and Middle Pools the methods have fairly comparable results, but we get considerable difference for the other pools. When choosing one, I would go with the random sampling as being the most accurate. You can see that as we go from South Pool up the lake to Gatlin, vegetation progressively decreases.

We take three weight measures on plants. First, we take a wet weight measure, which is the plant taken out of the lake, shaken off, and weighed. Then there is a spun weight. We put it through a washing machine to remove all the external water and weigh it again. Then we do a dry weight, after it is dried in an oven for 24 hours at 105 degrees Centigrade.

The ratio between dry and wet weight for hydrilla and pondweed is about ten percent. For nitella and *Vallisneria*, eight percent, close

to nine for Vallisneria. The correlation coefficients are generally pretty high.

I was looking to see which measure had the least variation and was going to analyze from that point on. I suspected the dry weight was going to be the least variable, having less external water which is more variable. But it turned out that wet weight was less variable. So, everything that you see will be in wet weight, since it is the least variable.

Back to the weight ratios--a T-test between the percentages for dry and wet weight. It turned out that the only significant differences in weight ratios were between Nitella and Potamogeton, and between Vallisneria and nitella. It is interesting that hydrilla and nitella aren't different at all.

Random sampling of the lake was done just at stocking time and will be done annually at the same time. It gives the percent occurrence of total vegetation on each of the major species, broken down for each pool. South Pool has the most vegetation in the lake by percent occurrence, and the average crop is about the same for the major pools.

The plant is weighed, but roots are excluded since the amur is not supposed to feed on the roots. This is a plus- or minus-90 percent confidence interval.

Hydrilla is found as a major component in only two pools in the lake, South Pool and West Pool. It is dominant only in West Pool and has 24 percent of the area there.

Pondweed is well dispersed throughout the lake. It is about equal in all pools but doesn't really contribute a major portion to the biomass in any pool except East Pool, where it is the dominant plant.

Nitella is probably the most dominant plant in the lake. It is found in all pools, but mostly South and Middle Pools, and has a considerable biomass, more than any other plant.

Vallisneria is at a low level in all pools, but it does contribute significantly in East Pool.

Transect samples are taken at 100-meter intervals monthly and yield about 200 samples per month. In West Pool, hydrilla is just

tremendous at about flowering time and has dropped off since then, which is normal. It also shows a good bit of growth in South Pool, which is dropping off. It is at a low level in our other pools.

For Potamogeton, there are not really any good trends at all. When one pool goes up and another one goes down, you can't pick out any seasonal trends or increases or decreases.

Nitella, which has the greatest biomass in the lake, has essentially the greatest density, but most of the pools are quite similar. There is a consistent trend of a strong winter dieback and then a strong spring regrowth with a lesser late summer dropback and then a fall increase.

Vallisneria is quite variable with conflicting trends, showing a tremendous growth in the winter for one pool but a drop in the winter for another.

We have 16 permanent plots which we sample with a diver every month. The stem density shows a fluctuation similar to the biomass, with the strong winter drop and the strong spring regrowth, then a summer drop and a fall regrowth.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF SUBMERSED AQUATIC PLANTS

by

John Bateman

Lake Conway is a fairly urbanized area. There are a lot of residences around. There are a lot of major highways that are nearby or come within a distance where they discharge their storm drainage water into the lake. In the past we have tried to eliminate as many of these problems as possible to keep the pollution out of the lake, but some of the existing systems that were there before, we could not do much about.

We also have septic tanks on most of the housing in the area. We have on several occasions gone out and tried to determine if these septic tanks were leaching into the lake, but we have never been able to determine this through studying the coliforms, so we don't know. We suspect not, because these soils are fairly good for septic tanks.

We have now completed about a year and a half of sampling on Lake Conway. As a result of these efforts, the Pollution Control Department is confident of its capability to determine the nature and degree of any significant changes and trends in the water quality that occur due to the introduction of the carp.

These determinations can be made by comparing present water quality against seasonal and long-term characteristics. However, due to the adaptive nature of a large body of water, such as Lake Conway, and seasonal effects on the local environment due to man's activities, we still have a lot of construction going on out there.

These things we are also going to have to account for. It is very likely that an analysis will be required for a number of years to isolate such effects from the changes brought about by the introduction of the white amur.

In addition, the capability to detect changes in the water quality is also dependent upon the number of fish that are introduced. Thus, rapid changes associated with overstocking would be quickly noted, while subtle changes associated with understocking would require more time.

As far as the present condition of Lake Conway is concerned, Lake Conway has good water quality. It also is used quite heavily by the local population. As I mentioned earlier, we have been carrying on a chemical control of the hydrilla problem in the lake through taxation of the local residents. They imposed a tax to take care of the lake, and we have matching state funds that come from the DNR.

I would say the water quality is almost as good as the Butler chain of lakes, and I think that is a baseline for any pristine body of water.

Some of the parameters we will look at today are DO, BOD, nitrogen, phosphorus, chlorophyll a, and carotenoids. We took the data that we gathered for WES, and averaged all the samples we took on a particular parameter throughout the five pools of the lake for each month. We also collected some data through the Pollution Control Department from 1972 through 1977. In all cases these won't line up and there will be some variation, but for some, like dissolved oxygen, the trend is pretty constant and it shows a seasonal trend.

On BOD we see a little variation, and we see a seasonal trend. I think enough background data has been taken to determine any changes that might occur.

Nitrogen appears pretty steady throughout the months of the year, and that pretty well correlates with the data we had historically from '72. We have data that goes back as far as '67, but it wasn't on a regular basis so we didn't include it in the study.

Total phosphorus is somewhat variable but again it shows the same trends, mostly seasonal, that we can predict.

As you might expect, chlorophyll varies quite drastically. We had some pretty wild variations. As we pointed our earlier, we had a very cold winter, and we have had some high chlorophyll counts this year. So, I don't know whether we can try to relate those two from historical data to the latest or not. Understand that the last data, between '75 and '77, were from an intensive sampling program once a month and so is probably the most reliable.

Again, the carotenoids tend to follow the same trend.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Dr. Ray McDiarmid

In preparing some of the remarks we are going to make today, we ran into some fairly interesting, potentially interesting, questions. One of those questions related to preparations of graphs. Is it better to present your temporal data, seasonal data, in monthly increments or weekly increments or daily increments?

When you have only been working on the project, Lake Conway, for two and a half months, it doesn't make any difference whether you have two and a half increments, ten increments, or 70 increments. I preface my remarks with those comments so that you will be better able to understand what we are going to say.

What we are trying to do is determine the composition of the fauna, ascertain habitat requirements, seasonal distributions and abundances, establish quantitative baseline data for population estimates for some of the more important species, and monitor any changes that occur through the next several years in terms of those selected species, with the hope of being able to ascertain any changes in density, abundance, distribution, or other measures of fitness as it relates to the introduction of the amur.

Our approach has been to select, after some relatively quick but detailed surveys, seven permanent sampling sites with selection based on a consideration of the variables that we think are important. These are variances in depth in the system, differences in substratum, sand versus high organic content, and distribution of the major vegetation types, both littoral and deep water.

What we have selected then are seven permanent sites, five littoral and two deep water. These include, at least in the littoral samples, expanses of <u>Panicum</u> grass, <u>Pontederia</u>, <u>Typha</u>, waterhyacinth, <u>Nuphar</u> and open beach. In terms of the deeper water samples, <u>Potamogeton</u>, <u>Vallisneria</u>, nitella and hydrilla.

At each of these permanent sites, at ten-meter intervals, between 150 and 500 stakes are put out. These stakes then are used as our permanent sampling sites which are monitored on a weekly basis. In this program we hope to monitor every site at least twice a month.

In addition to this program of sampling, which involves primarily a mark-and-recapture study, all organisms that are captured are sexed, weighed, measured, marked, and released. We are also doing destructive sampling in other areas of the lake, with the idea of obtaining reproductive data to allow us to interpret changes in age and density within the population. Also, stomach analyses will help us relate any changes that we find to the composition of, for example, the benthic organisms or the macrofloor.

To date we have turned up 21 species which we estimate to be about 60 to 80 percent of the fauna that occurs in the lake. This represents about 650 total organism captures, of which about 400 are represented by one species. These include three salamanders, eight frogs, three snakes, six turtles and one crocodilian, the alligator. We have selected nine of these species for special concentrated work.

We think we are starting to find the factors that are important in controlling the distributions of some of these species, specifically with reference to habitat types. Some of these are based on either biomass, feeding habits, or other factors. Hopefully, accumulating enough baseline data will allow us to make some predictions about consequences of any change in the lake quality.

We are running into a couple of problems which have been briefly mentioned. There is a considerable amount of movement and activity in the lake in reference to motoring activities. One of the species which we are monitoring extensively, one of the large herbivorous turtles, to date has suffered at least 14 percent of the extensive damage on all the animals produced by motorboat props.

The alligator populations are declining fairly rapidly, primarily through this destruction. In the time that we have been out there, the last six months, the Fish and Game people tell us that three of the large 'gators in the lake are gone. We know of two nests, and we can

predict some recruitment into the population, but at that rate of losing large animals, looking at the largest organism on the lake, the alligator, is going to be rather spurious.

By looking at other organisms, we hope to be able to detect, through movement patterns of known marked individuals, shifts in food habits, weight losses, or some other fitness measure--changes that may in fact be the result of the introduction of the amur.

One other factor which has recently come to our attention is the continued destruction of natural habitat along the shore, which is relatively limited, anyway. We are in the process of establishing sites which will look at changes in composition of the fauna through beach destruction. We can then consider this in our interpretation of any changes that may be a result of the amur introduction.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Thomas Fontaine

The grant that I am working on has two facets. One is a mathematical model to describe Lake Conway and hopefully predict what the white amur will do in it; the second part is determining the productivity of the lake, that is, how fast the plants are growing and the related metabolic measurements.

Our three transect lines emanate from different types of shorelines, so we are covering the whole gamut of residential to natural shorelines. On each of these transects we are measuring in shallow, medium depth, and deep areas, so we cover all the vegetation community types also.

In the shallow areas we are measuring the productivity of Vallisneria communities, Potamogeton communities. We are also doing the open water zone which is dominated by phytoplankton.

One of the things that we measure is the temperature profile of the lake. This is very important for us so we can tell such things as when the lake will turn over and release phosphorus from the sediment.

In a summary of the productivity measurements for an average square meter of lake surface, there are three peaks of gross production. We have a spring peak, a fall peak, and also a lesser peak in the winter. We also have peaks in respiration which seem to coincide.

Benthic invertebrates are highest during the winter, which we think we might be able to ascribe to this peak in respiration. Most interesting, there is a trough in the summer. If you remember, the lake stratifies during this time. There is no mixing of the waters so nutrients can become depleted very fast in those waters, thus limiting the productivity. One other factor perhaps contributing to the summer dip in productivity is the solar radiation pattern.

Summing up, we have a lake that shows some definite seasonality, fall and spring peaks of productivity, also warm in the winter. We have

respiration lines that seem essentially to follow the production lines. The lake fits into the eutrophic range, about 900 grams of carbon per meter squared per year. Lastly, the productivity measurements have been very good in helping us construct the model.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Dr. Katherine Ewel

B. GENERAL CONSIDERATIONS

The reason such a tremendous amount of effort has been put into the Lake Conway project, to look at all the different parameters, is so we can try to determine a pattern in the kinds of changes we have seen in each of the parameters in the lake. We would like to be able to use this pattern to predict how other lakes might respond to the introduction of the white amur.

Finding this pattern is a little bit like putting a jigsaw puzzle together. You start with the corners and the edges and then you fill in from there.

In working with lakes in the Southeast, we don't have any corners, we don't have any edges. With the Conway project we know how big the pieces are, but we have got to find out just where the edges and the corners fit.

I have been working for a couple of years now, trying to put together a model of Lake Conway which will be specific enough to describe the changes, to incorporate the changes we have seen from the data we have just heard, and also that will be general enough to apply to other lakes as well. These are the pieces of the jigsaw puzzle. I will try to point out some of the edges that we know about.

The main thing, of course, are the macrophytes. I have grouped hydrilla with nitella and Vallisneria and all the others because we don't think the white amur distinguishes between these different species of macrophytes.

We have three kinds of algae. One group we have put together with the macrophytes, the periphyton. These are the algae that actually grow on the macrophytes themselves. The vascular plants, pump nutrients from the sediments into the water. The periphyton and the macrophytes have a

kind of symbiotic relationship. There is exchange of nutrients and carbon between them, so we think that they act pretty much as one organism.

We also have phytoplankton, the algae growing in the water itself. These, we think, are sustained in large part by the nutrients that are pumped out from the macrophytes. In comparing the amount of nutrients that washes into the lake, as we saw from Don Blancher's budget, we think that this is relatively small compared to the amount of nutrients that are pumped in by the plants.

We also have epipelic algae or benthic algae, which includes a lot of the filamentous algae that a lot of you have seen growing along the bottom of the lake. We think that this group of algae uses the nutrients that are released at a very slow rate from the sediment. So we have three groups of algae, four groups of plants, which are fairly distinctive in terms of their behavior in the system.

The rest of the lake is pretty straightforward. The zooplankton feed primarily on phytoplankton, also on periphyton. We are distinguishing three groups of fish--herbivorous fish, things like the shad and so forth which eat a wide variety of organisms, including detritus; also, primary predator fish, and we have separated out the young because the diet of the young tends to be more like the herbivorous fish, and these grow into primary predator fish which then eat benthic algae, zooplankton, these sorts of things; and then the secondary predator fish like the largemouth bass and the pickerel that eat the smaller fish as well as benthic invertebrates.

The values for productivity are from the measurements obtained in our studies that Tom Fontaine told you about. We have estimated consumption by the different groups of organisms, and it is mostly the periphyton that are consumed. Very, very few things actually eat the macrophytes.

We look at respiration and we try to estimate the amount of nutrients that are pumped out by the plant and we include the tubers also, looking at formation and termination of tubers.

We know a little bit about the white amur. We know, for instance, that the young white amur will eat plants at a certain rate and they

will grow at a certain rate for about the first three or four years, but we don't know very much beyond that. We don't know, for instance, the rate at which nutrients are pumping from the macrophytes, so we don't know how much of an effect the white amur is going to have on this. We have had to make a lot of guesses along these lines.

We started out with an estimate of 7000 fish and we decided that a mortality rate of about 10 percent per year might be a reasonable one, although this is one of the things that we don't know. If we look at total biomass, not per fish, but total biomass, we see a fairly rapid increase, followed by a leveling off. After ten years each individual fish weighs on the average about eight kilograms.

We have the seasonal pattern programmed in so that you get an increase in macrophyte biomass in the summer and then a decrease in the winter. At the end of ten years we are down to about ten percent of the original level.

Because the macrophytes are cut out, because the nutrient pumping is cut back, we see a fairly significant decrease in phytoplankton levels but we see an increase in the epipelic algae. These are the benthic algae that grow on the bottom, which get their nutrients, we think, from sediments. When the macrophytes and phytoplankton are removed, that takes out a lot of the shading effect so that we see an increase in these benthic algae.

Zooplankton don't die out; they just go back to very, very low levels because the periphyton and the phytoplankton, both very significant parts of their food chain, are removed.

The benthic invertebrates, however, do increase. These feed primarily on detritus, but since they feed also on epipelic algae, the increase in this food source allows them to increase quite a bit.

The herbivorous fish show some increase but eventually a decrease. The primary predator fish decrease and the secondary predator fish increase quite a bit up to ten years. This may be a very temporary sort of thing. One of the factors that affects them is their ability to find their prey, so with the cover, the macrophytes, being removed, these fish are better able to prey on the smaller fish. There certainly will

come a time when there won't be that many smaller fish to prey upon.

The relationships between the fish are still not certain since we didn't have all the fish data at the time we did the model. One of the most interesting things, I think, is the effect of the white amur on the amount of detritus in Lake Conway. Initially there was an increase, followed by a decrease, which I think is very significant.

It is common sense when you think about it. The white amur by eating away the plants is, of course, eroding the rate at which carbon is fixed, at which biomass is manufactured in the lake. So there is less stuff going into the detritus, but the detritus still has the same rate of respiration.

After a period of time it starts to decrease, and this suggests that perhaps the white amur may actually reverse successional trends in this particular lake. This is something that I don't think we thought very much about. It would be a little hard to measure, but it is something that I think perhaps we ought to look at very, very closely.

I don't know whether it is good or bad, but I think it is one thing the model has shown us that might be an important parameter to take a look at. Thank you.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF SUBMERSED AQUATIC PLANTS

by

Janice Hughes

Louisiana adopted a policy in July of 1972 concerning introduction of grass carp into the state. This policy states that no releases of the fish into state waters will be made, that possession and introduction into Louisiana remain prohibited in accordance with public law, that first priority of research in the state will be the development of sterile carp with all of the research being conducted with these sterile fish, and that none of the carp family be possessed, sold or caused to be transported into Louisiana without written permission of the Louisiana Wildlife and Fisheries Commission.

Therefore, the only research conducted from 1972 until 1974 was with the hybrid carp, using the Israeli carp female and grass carp male. This fish was thought to be sterile but further tests proved the fish was capable of reproduction. After this was discovered, we had no particular interest in any further research with this fish.

In November of 1973 the first wild grass carp was captured in Louisiana in the Quachita River system. Since then reports have been more numerous and widespread. Today a total of over 100 grass carp have been captured in all of our major river systems in Louisiana. The largest confirmed fish weighed 20 pounds, with several unconfirmed reports from commercial fishermen of fish weighing over 30 pounds.

With all of the catches of wild grass carp showing up in the state, the Fish Division decided that we needed to initiate several research projects to determine what effect these fish will have on our native fish populations and vegetation.

Projects were initiated at four universities and by the Department of Wildlife and Fisheries. Our project, entitled "Grass Carp Investigations," was initiated on July 1, 1974, and will run for five years. This is one of the federal-aid projects that we have.

The project is divided into two studies. The first study is

production of grass carp and evaluation of their effects on fish population. The second part is evaluation of the effectiveness of grass carp in controlling aquatic plants.

We selected four lakes in Louisiana for this project, ranging in size from 30 to 250 acres. These lakes had to meet four criteria for this research: they had to be the right size, within the criteria we set; they had to have an established fish population; they had to have an aquatic vegetation problem; and there should be no escape for the fish.

Two lakes were selected in central Louisiana and two in north Louisiana. I would like to give you a brief description on each of these lakes and tell you some of the preliminary results that we have obtained.

The first of the two central Louisiana lakes that I will discuss is Belson Lake. It is 150 acres in size and has an average depth of about five feet. When we selected the lake, the vegetation was sparse, primarily coontail. The fish population averaged around 200 pounds per acre and was predominantly large bluegill and redear. It was also a really good buffalo lake.

We stocked grass carp in December 1974, with 30 six-inch grass carp per acre. Six months after stocking we could notice that vegetation was reduced. Eighteen months after stocking the vegetation was eliminated. We do have some duckweed showing up now, and we are getting some cover in one end or so of the lake.

One year after stocking the fish weighed from nine to 15 pounds, after one and a half years, 17 pounds, and so on. Two-year-old fish are weighing 17 pounds. Actually, after the initial growth the first year, they have not changed all that much.

The other lake in central Louisiana is Low's Lake. It is 30 acres, has an average depth of five feet, and very dense vegetation, composed primarily of coontail and Potamogeton. The lake was stocked with largemouth bass, bluegill, and crappie two years prior to when we started working on it. The fish population averaged around 300 pounds to the acre.

This lake was stocked with 30 six-inch grass carp per acre in

December 1974. We noticed a slight reduction in vegetation in six months and a significant amount of reduction in 18 months, but we still have quite a bit of vegetation in the lake.

However, quite a few large holes have come into the lake. As a matter of fact, the first year I was not able to make a rotenone set, but now I have some areas where we can get the net down.

A year and a half after stocking the fish weighed 11-1/2 pounds. Two years after stocking the fish ranged from 10 to 20 pounds.

The two lakes in north Louisiana were stocked almost one year after the ones in central Louisiana. The first lake, Williams Lake, is 250 acres and has an average depth of about 10 feet; vegetation was scattered, primarily milfoil, coontail, naiad, and bladderwort. The fish population averaged around 50 pounds to the acre. It has a high percentage of bluegill and redear but most of them are of the intermediate and fingerling size. In November 1975 this lake was stocked with 15 six-inch grass carp per acre, which is half the stocking rate used for the lakes in central Louisiana.

One year and nine months after stocking, we have noticed a great reduction in vegetation. The only grass carp that was captured in this lake was an 11-inch grass carp taken out of the throat of a 7-1/2 pound bass. We know there are still some in there, although we haven't been able to catch them.

The other lake in north Louisiana is Myers Lake. It is 75 acres in size and has an average depth of around five feet. Vegetation is very dense, primarily milfoil and coontail. Fish population averaged around 200 pounds per acre, with a large population of buffalo, German carp, and gar. This lake was also stocked with 15 six-inch grass carp per acre in November 1975. One year and nine months after stocking, we noticed a great reduction in vegetation and we have not captured any grass carp from this lake to date.

In June of this year Bob (Johnson) went to this lake to make his checks on the vegetation. He found that it still had quite a bit of vegetation. In August I went there to do fish populations and I could

really tell a big reduction, so most of the vegetation was eaten during that period.

As I mentioned previously, this project will be concluded in June of 1979. At that time the data will be analyzed and published and the resultant report will be used in future policies on grass carp and introduction into Louisiana waters.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Scott Henderson

First of all, I am a fishery biologist and do fishery research in the state of Arkansas for the Game and Fish Commission. Our present emphasis on research in Arkansas is with yet another herbivorous fish, the silver carp, which is a filter feeder. It is extremely efficient at removing phytoplankton from the water body.

What we are faced with in Arkansas is a Potamogeton species, most of the pond weeds, Myriophyllum, coontail, and the rooted and floating filamentous algae. These are our main problems. We don't have any problems with hydrilla or waterhyacinth at this point.

They asked me to briefly discuss our research with the white amur or the grass carp in Arkansas. That is pretty simple because we are not actively involved in research any more. The status of the grass carp in Arkansas is that it is a regular management tool that we use throughout the state for aquatic vegetation control. It has solved our problems. We are not devoid of aquatic vegetation in the state by any means, but we feel that we no longer have any significant problems.

Since about 1968-69, when our program with the grass carp began and we stocked one or two small, topographically isolated lakes with the fish, we have stocked over 50,000 acres of water in the state of Arkansas with about half a million fish. This has been done primarily in the public waters of the state that are managed by the Arkansas Game and Fish Commission. We feel that the fish have solved our aquatic vegetation problem.

At this point, since these fish have not reproduced at all in any of the waters in the state, we are presently in a maintenance system. Our restocking is somewhat similar to the models you have seen. We find in some cases, after seven years or more, that we are seeing some recurrence of vegetation, and we periodically restock with small numbers, about two or three to the acre.

We have data from these lakes over the years, but this has not been an extensive monitoring program such as they are discussing with Lake Conway. We have taken fish population samples annually, as most of our work, obviously, deals primarily with the fish populations that are involved.

We have seen no ill effects at all that could be attributed directly to the grass carp. The only effects that we have seen, detrimental or otherwise, are a direct result of the vegetation removal. We feel that these same effects would have taken place no matter how that vegetation was removed.

One example, we have seen--and it is a matter of opinion whether this is detrimental or not--is a shift in species in some instances from redear bream to bluegill. Of course, I think that would happen as a result of vegetation removal, whether it be mechanical, chemical, or whatever. The grass carp itself has shown no direct effect on any of these populations.

In my estimation, the question is not whether the grass carp will do the job of cleaning up the vegetation, nor is it a matter of whether it should be used. But I think that some emphasis should be put into determining individual priorities for water use in different areas, different geographic locations, and naturally there will be some differences in the use of the fish. I feel it should be used for what it is, as a tool for aquatic vegetation control.

There will be some variations in stocking rates and in its use in various parts of the country. I think that the major question left before us is how to go about making the best use of what we have found to be a very good tool for vegetation control in the public waters in Arkansas.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Forest Ware

I was told that there were a lot of proponents of the fish on the panel but they needed to have somebody who was an opponent. So I was selected. I don't know how I gained that reputation, but be that as it may, we will take a shot at it.

Actually, the policy with the Florida Game and Fish Commission is that of a cautious attitude in working with this fish. We have been involved since 1969, and I don't know of any research phase with grass carp that I, or part of our staff, haven't been involved in. We will give you a quick cap on what has been going on and possibly some of the defense for our cautious attitude.

The work got its kickoff in 1969 when the Department of Agriculture started some small tank studies at Fort Lauderdale, and went from there into ponds around '71-'72. It primarily showed that the fish would eat weeds.

Two missions were generated in about '72, in the preliminary work. One was to develop the management techniques for numbers, stocking rates, and manipulation to control weeds in small ponds; number two involved the environmental impact considerations. That is where we really got concerned, really got involved.

Our principal target plant, of course, is hydrilla. One thing people outside Florida get a little confused on is that the natural lakes of Florida are dependent upon aquatic vegetation for maintaining their biological health. In almost all situations with those lakes, if you remove the aquatic macrophytes, you have problems, particularly in game fish production.

We don't have a diverse fauna in Florida like you have in the temperate zones. We don't have a lot of cyprinids, carp, or buffalo. It is a rather unique system, very sensitive. They are shallow lakes, primarily with Centrarchid populations, bass, bluegill, black crappie,

redear sunfish, a few catfishes, and a few small minnows.

When you come along and put in a fish with the high poundages that we have found in working with grass carp for hydrilla control, we do expect some impacts. This is where we feel that we have a major obligation, in defining these impacts.

The first significant study completed, and probably the only one that has been completed to date, was the controversial four pond study. Some of you may be familiar with it. We took four small lakes in Florida and stocked carp at 40 pounds per acre. In two of the lakes we monitored the game fish populations through time, before and after, and in the other two, primarily the other parameters, water quality, vegetation, etc. As Mr. Miley, my counterpart with DNR, will tell you later, there has been quite a bit of disagreement among staffs on interpretation of this data.

One thing was significant. In the two fishery lakes, there was significant impact on that production, so we are concerned. This has been basically our reason for saying, "We have got to go further, folks."

We have got a lot of sensationalism about the "great white hope." The paper says this thing is going to cure all our problems, and in some situations it has worked. I think Lakes Holden and Bell have had pretty good results, about 20 fish per acre on hydrilla control.

Conversely, we stocked Lake Wales, which had been our principal study in '73, with 36 fish per acre. This was a 300-acre lake totally vegetated with hydrilla, some Vallisneria. The fish averaged about ten ounces in size in '74. In '76, two years later, there was no significant change in the hydrilla population.

We had a bunch of extra fish at the hatchery, so we went back and dumped in another 100 fingerlings per acre to see just what it is going to take, biomasswise, to bring hydrilla under control in a lake situation. We are seeing some change this year. It is now kind of "nip and tuck" whether the hydrilla will be checked or if it is going to bloom back. We will know next spring.

Some of the people at the USDA and University of Florida, in their pond studies, found that using the fish alone, you had to get up to a

magnitude of about 200 pounds of carp per acre for hydrilla control. They have shifted that direction with the integrated approach, something we may see similarly on Conway, where they knocked the vegetation down with chemicals, then slid in about 50 pounds per acre, and have achieved the desired results.

We have one really interesting study on which I think we are going. to have some information in about 30 days. One of our problems in this has been that we put in X-number of fish, and if the weeds don't go away, then the bass ate up all the carp. Nobody knows this, but we are going to look at it.

In Lake Conway, a study lake in Orange County, we have a couple of hundred acres that historically had hydrilla which were wiped out chemically. In '74, 25 six-inch carp per acre were stocked. This past summer hydrilla returned, and we have about 40 to 50 percent of the total area of Conway vegetated with hydrilla.

We have now set up to try to estimate the population size of carp in Baldwin. We are going to do this through a selective rotenone treatment. To my knowledge it will be the first attempt at estimating carp populations, at least in Florida lakes, when the situation did not work. Hopefully we will understand better what the population density and biomass of carp were in this particular situation that did not work.

We are now working in two new directions in Florida. We are going to try a spawning experiment with our DNR colleagues in a stream that flows into a reservoir, Deer Point in northwest Florida, which is stocked with carp. We are going to put in about 10 million fertile eggs this spring, monitor them downstream, as you would with egg nests, for hatching success, viability, etc.

The other thing is a situation, like Lake Holden, where we now have the fish and where it did do the job. Now, how do we get them out. We have got all the weeds eliminated and we would like to have some vegetation in the lake.

This has been a real challenge, trying to retrieve these fish once you get them in the water, because the growth rate is good in Florida--ten pounds the first year, 20 to 30 pounds second year growth. Any of

you who have worked with them know they are wary and difficult to recapture, and so we are developing some studies along that line.

PANEL DISCUSSION
THE WHITE AMUR FOR MANAGEMENT OF
SUBMERSED AQUATIC PLANTS

by

Woody Miley

Any discussion of grass carp in Florida I think should be put into perspective by a short discussion of hydrilla in Florida.

We got hydrilla in Florida approximately in 1960. By 1965 it could be found in about 10,000 acres. By 1970 hydrilla could be found in approximately 50,000 acres of Florida. By 1976 hydrilla was reported to be in approximately 700,000 acres of Florida's two and a half million acres of fresh water. About 200,000 acres of this was considered dense infestation.

Although aquatic macrophytes are a very necessary part of the aquatic ecosystem, you can definitely get too much of a good thing. Adverse effects from excessive vegetation are documented in the literature. Effects on fish populations include overpopulation and stunting. No matter what the intended primary use of a body of water, leaving hydrilla alone is not one of our choices.

We have been researching the grass carp in Florida since about 1969 and have accumulated a great deal of data. Most of the researchers in Florida, including all the active researchers within the University system, are convinced that grass carp can be used as an aid in controlling hydrilla with minimal impact on the aquatic ecosystem.

Dr. David Sutton from the University of Florida and myself spent nine weeks on a European junket. We went through several countries in Europe, including the European portion of the Soviet Union. In the Soviet Union we were joined by Dr. John Stanley of the Department of the Interior. Dr. Stanley is considered the U. S. expert on grass carp by the Florida Game and Fresh Water Fish Commission and was sent on this trip at the request of this agency.

The main purpose of this trip was to get some handle on the reproductive potential of grass carp. Other than in the Soviet Union, the grass carp does not reproduce in Europe, although it is stocked widely

and has been in some of the major river systems over 20 years.

Within the Soviet Union, grass carp have reproduced in five systems. In the natural systems where the fish reproduces, they constitute no more than five percent of the total commercial harvest. In addition to the natural reproduction in these systems, they are stocked annually with dozens of millions of artificially produced fish.

The Soviet fisheries biologists agree that if this massive stocking program were ceased, the natural populations would die out because natural reproduction would not be sufficient to maintain populations. The Soviet literature gave us considerable problems in trying to make predictions concerning reproductive potential of the grass carp in Florida and in the U. S.

While in the Soviet Union we learned that one of the major papers was grossly in error and that the larval fish identified in the paper were not even grass carp. There were also some translation errors. The Soviets don't differentiate between different species of phytophagous fish.

When they refer to phytophagous fish, they are talking about grass carp, silver carp, and the biggie. Then further down a few sentences or in the next paragraph, they make reference to grass carp, and the translation would come across as the whole thing relating to grass carp. This caused us a good bit of trouble.

The requirements for successful spawning are much more narrow than we had at first thought. Even in the areas where they spawn, spawning is sporadic and quite weak. Dr. Haller from the University of Florida and Bill Bailey from Arkansas studied the same type of questions in Japan, Taiwan, and the Philippines, and came back with identical conclusions from spawning sites in those areas.

Besides problems with natural reproduction, the Soviets have shown predation to be very instrumental in the failure of grass carp to establish large populations. Work done in Florida by the Game and Fish Commission, by the Department of Natural Resources, and in particular by Dr. Jerry Shireman of the University of Florida, substantiates this

theory and indicates that we can expect the same results in our predator systems in Florida.

As far as impact noted in the Soviet Union and throughout Europe, there has been no adverse impact on commercial species of fish. There has been no impact on water quality. There has been a positive effect shown on sports fishing, except in a few isolated cases where grass carp were overstocked and all vegetation was removed. Then an adverse effect was demonstrated on such vegetation-dependent species as the pike.

The prediction and conclusions that came out of this trip were unanimous. They were that grass carp will probably lay eggs somewhere in the U. S., in particular somewhere in the Mississippi drainage, but the possibilities of the fish amassing a large population, large enough to have an adverse impact, are very slight. Thank you.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Moderator - C. B. Bryant

The function of the aquatic plant control research project meetings, it seems to me, is to assess control technology effectiveness; at least that is certainly a large part of why we are here. To the degree that we succeed in that assessment we have succeeded in making this annual meeting valuable.

How might we assess control technology effectiveness? Maybe as a start we could categorize control technology effectiveness three ways, as follows: control effectiveness as a percentage of some sort or as time related; secondly, cost effectiveness; and third, other effects, things political, ecological, and whatever else is left over.

I would hope that this hour might produce some sound cost facts on harvesting aquatic vegetation, facts that we could take notes on and at least have to compare against the other choices. So, I would charge my panelists to give us, where possible, solid cost information in dollars and a harvest rate of some kind, if you have any information, in tons or acres per hour.

There are two planes to be met: first, costs if possible; secondly, a position statement on whatever you want to say; and third, I think it would be nice if this panel could come up with a consensus on what is needed in the way of research or hardware where improvement in mechanical control could be realized.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

John Neill

For some strange reason, the idea has developed in the minds of some professionals and the public at large that harvesting a crop of plants should be able to reverse the whole process of eutrofication immediately, thereby preventing regrowth, and that it should not cost any money because good water quality is a free resource. And of course, everybody's problem should be solved at least the day before yesterday. Of course, this doesn't happen.

I believe that harvesting has not taken proper place because good thought, good studies, good planning, and reasonable funds have not been directed toward what I belive to be a valuable tool in managing lakes where eutrofication manifests itself as an overabundance of macrophytes.

There is no single magic solution which can be applied to lakes with problems. Lakes are like people. Each one has its own genetic background which establishes what you have to work with in terms of morphometry, temperature regimes, and basic chemical characteristics. Like people, culture influences are superimposed on a genetic base, which in lakes includes changes man creates in littoral areas, flow regimes, nutrient resources, and the introduction of exotic biota.

Generally our approach to lake management to date has been poor. We look at things in isolation rather than using our ingenuity and the tools at hand, blunt as they might be, to achieve realistic objectives for each lake. In my mind, all the tools that we have discussed at this conference, including the chemical, biological, and physical, have their place and their limitations.

Chemicals should play a role in controlling the isolated problems where acreages treated do not constitute a significant portion of the large lake. Potential for biological controls is good but difficult to hold in balance at the precise levels required in a control program. Harvesting is the one technique that has the potential for truly

managing lakes populated by an overabundance of macrophytes.

Perhaps I could illustrate this by reference to the program that we have been associated with in Canada. We have a number of lakes where macrophytes are problems. Milfoil came to us in the late 60's and it created some significant problems.

Our control agency, the Ministry of the Environment, wished to evaluate harvesting as a technique and we have been involved since '74, using a variety of machines, two Aquamarine harvesters and one of Tom Kelpin's dreams. Our contracts have been up to a thousand acres annually.

The Ministry has measured the effects and benefits of harvesting on such things as water quality, the fisheries, public response, etc. They have also supported us in studies looking toward the utilization of the biomass that was removed in the harvesting projects.

I believe that for harvesting to become accepted and become a major tool in lake management programs, somewhere along the way the price has to come down to the point where local agencies, perhaps with some direction and financial assistance from senior governments, can stimulate use of this tool. The way I conceive that costs come down is by the improvements of the mechanical design and capabilities of harvesting equipment, and secondly, by recovering some of the costs through the use of the biomass harvested.

Our work in this regard has advanced to the point where today, this afternoon sometime, we are launching a new harvesting system on which we will be doing some evaluation work this fall.

We are looking for something in the order of three times the production of the conventional harvesting system at about the same operating expense, and we hope to resolve some of the problems which exist with the conventional type equipment, such as damage to cutter blades in front, which tends to reduce your production by limiting the forward speeds where you cut and harvest at the same time. We hope to solve some of the material handling problem by grinding the plants and handling them as a slurry.

The recovery of a useful product perhaps can pay for some portion of the cost. We don't ever see it as being a self-perpetuating thing,

but if it did nothing more than provide for transportation of harvested weeds, it would be a major benefit to the system.

I will not be able to devote much time to the potential for utilization of harvested plants, but perhaps I could just touch on our research for a moment. The Ontario Ministry of the Environment, as I mentioned, has supported this work, and our objective has been to develop a product of value to offset a portion of the harvesting costs. To implement these studies we combined the limnological skills in our organization with colleagues from the University of Guelph who are our agricultural group.

The study started with a careful analysis of the plant materials, followed by pilot scale studies at the college facilities. We have been successful in composting aquatic plants in seven days. Evaluations of the compost in greenhouse tests using vegetables, grasses, and flowering plants have encouraged us to complete this work. We have developed a process in the field and will be carrying on with commercial grower evaluations.

Our studies with animal feeds have centered on silages made from *Myriophyllum spicatum*. Last year we fed steers at the lake on a diet of milfoil, cardboard carton material, and some conventional additives. Their gain was identical to an equal number of controls. We were short of protein in the overall feed and hope to formulate in the future, as part of an ongoing program, a diet where we would add fish products taken from coarse fish in the area to bring the "economic level" down to something which would appear to be practical.

If successful in this study, let us look where it puts us in harvesting. Our current harvesting contracts are for $150 per acre, of which 30 percent is the cost of trucking and disposal. If this could be paid for by the use of the harvested biomass, this brings the cost down to the order of $100 an acre, which then becomes competitive with the chemical control.

Through mechanical improvements, we are looking for a reduction of about half in our costs. This then takes us to the order of $50 per acre, a point where, I think, we are highly competitive and where local

agencies could support a viable management program based on harvesting.

The theme of this program is aquatic plant problems and opportunities. I put it another way, and say we should be turning our problems into resources and then you don't have a problem any more.

Unfortunately, these things don't happen by themselves. It takes foresight on the part of enlightened resource managers to support the development of these kinds of solutions. Some encouragement in the form of demonstration projects and longer term contracts will allow the entrepreneur to invest the time and the money necessary to provide this tool to aquatic plant management. Thank you.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

P. A. Smith

The Corps does have a need, as was mentioned, and we of the Corps at WES want to be a part of it. We are trying and we are taking a good hard look. The last 90 days have been rather hard, but we are going to come up with some good data, we hope.

Customers like Bill Thompson of the New Orleans District are applying the pressure to us at Vicksburg, where the basic research data are being gathered, to come up with a workable solution in mechanical harvesting, if it is at all possible.

Our work is being continued on the assessment of the mechanical harvesting work that has been done through the past 50 or 100 years. Wherever you go you can find some elevators or conveyors, although most of them are rusty. The people have given up on them. We are going to try to come up with a workable solution.

Presently WES is looking at our second year. We are on the Withlacoochee River in Florida and the St. Johns River. Later on, Moody Culpepper from WES will tell you about last year's work.

During the winter, when we looked at the equipment that was available, we found that we would be right back where we had been unless we tried something using less energy, less cost. That is the whole key--if you move it, it is going to cost you something. So, for the St. Johns and Withlacoochee, we are looking at letting nature help us move these plants. Cut them loose and let them float. We have found they will float, but we also found that the river doesn't flow very fast, so that is a problem.

We are going to go ahead and complete the studies that we started. This will consist of cutting and transporting, whether this is by free-floating or whether we have to push it. We have done some of both. We have good data being collected, over the previous couple of weeks, on pushing hyacinths, towing hyacinths. We have found, I think to the

amazement of some of us, that as we went up in size, biomass of the plants, it didn't take much more to tow them along. Also it didn't require much more energy to push three times as many as it did the small amount. That in itself looks good.

If we could just get the river to assist us a little and flow properly, then we think we could cut down on this transportation cost. I am a firm believer that transportation cost is one of our major mechanical problems to overcome.

At this time we are cutting, transporting, loading, using a conveyor, and also we are doing unloading off the conveyor into piles for storing. We also study the decay, the period of time before we could go back to put more plants on a stack, maybe at the edge of a river or the edge of a lake.

We have been tasked to gather the necessary data this year and to come up with a RFP (Request For Proposal) to go out to all the industry, or any concerned citizen that thinks he can come up with a system. We will do this in early November or the latter part of October, so that we can get a return by 1 January, maybe the middle of December. At that time we will take another hard look, but I am not sure that we will come up with one person or one concern or one group of people that will have the system that is the answer.

After being on the river awhile and looking at the rivers and the lakes and at the floating and submersed plants, I think that maybe we will need an integrated system. Mayber parts of it we can use on the lake, parts on the river. Other parts can be used only at one location.

We must take a good hard look at the proposals we get back and then, 1 June of next year, we will have a workable system in the field. At that time we would go through another series of operational tests, gather this data, and then come back and take another close look at it, which hopefully will be much better than what we have at the present time.

I have a list of about six topics that I think we, the Corps of Engineer people and private industry, need to take a close look at. One is the cost per acre. John (Neill) came up with a good number

a while ago, 150. That's the best number we have heard at this meeting. Jacksonville had 270 and 400. Our numbers were somewhere near that.

Concerning harvesting rates, we at WES have a "magic" number, 80 tons per hour. That means that on some hyacinths, where you have 125 or 150 tons per acre, you do a lot of cleaning up and a lot of moving of plants, whether you chop them up and haul them out in small bales, whether you float them out on a barge, or whether you free-float them to the bank somewhere.

With hydrilla we found the maximum to be about 26 tons per acre. With that figure we could possibly get three acres per hour. That sounds good, but whether it is realistic or not, I don't know. We are going to try, although it may not be in the next two years.

After being in this program for six months I have found that gathering these new ideas is kind of hard to do because agricultural engineers are not interested in us because we talk of eradication, to begin with. John Deere and the various people I have talked to say, "Tell us how we can sell 10,000 machines and we will get in with you," but we are not talking 10,000 machines at the present time. So, we must take a hard look at everybody that has got a little idea that we think can help us.

We feel that we are getting pressured at little bit. Give us a chance to put 50 percent of ours back in the water, or can we put 50 percent? This is where we need some help. To get 80 tons per hour we might have to put 20 percent, 50 percent, back in the water, in the form of piles, as Jim McGehee has been doing. Also, maybe we can put it in a bale and condense it so it will go to the bottom and decay at a slow rate.

I hope at WES we can continue, even after we put out the RFP, basic research on mechanical control, whether it be cutting, transporting, or storage. Hopefully we will have a concerned effort from the OCE level to continue to do basic research in mechanical control.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Moody Culpepper

Last summer I tested the Aqua-Trio. This is the same equipment that the Jacksonville District now has on Orange Lake, just south of Gainesville, Florida. We tested the Aqua-Trio, in waterhyacinth and submersed hydrilla, where we removed all of the plants from the water onto the land. With the waterhyacinth, we worked in the St. Johns River and in the small canals adjacent to the St. Johns River, along and near Astor, Florida.

The equipment we used was the basic Aqua-Trio, the harvester, transporter, and shore conveyor, and two dump trucks. The density of the plants we operated in ranged from 50 to 150 tons per acre.

The rates of production we were able to achieve with this equipment were slightly less than five tons per hour. The cost of this was approximately $36 per ton, and based on the ranges of density we worked in, we are talking about $1800-$5400 per acre, which is prohibitive.

Then we moved to Orange Lake and the Withlacoochee River and got into hydrilla. We slightly changed the equipment makeup and used one harvester, two transporters, one shore conveyor, and one truck. The density of the topped out hydrilla ranged from 10 to 22 tons per acre. Our production rates in hydrilla ranged slightly less than 10 tons per acre, with a cost of approximately $20 per acre, or $200 to $440 per acre.

Based on the data that we took during the year, we concluded that transporting the harvested plants from the harvesting site to the take-out point on the land-water interface appears to be the major pacing problem in developing a high production mechanical harvesting system.

I have one other thing to throw out to some of the chemical people here. I talked with some of the operational people and asked for cost figures on chemical control of hydrilla. I was given a price of $200 per acre for chemical treatment of hydrilla, and I hope perhaps to get some idea if that is approximately correct or not.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Jim McGehee

I have some figures that you were looking for as to the costs. What we experienced for the period that we worked was approximately $400 per acre. If it were not for having to take the material out and put it onto the land, we could probably reduce that, to approximately $273 for this year's operation by taking off the conveyor and truck systems.

The State of Florida has spent a good deal of money in the past few years on mechanical control. The Jacksonville District is now sponsoring what I consider to be a pretty fair amount of research in mechanical control.

The results that we have had in the past few years, the work that WES is doing now, seems to be pretty encouraging. We all know that chemical control has some drawbacks and has some good features to it. Mechanical control is the same way. The same thing is true with biological control.

In the Jacksonville District, we think that we should try to take advantage, as operational people, of the good points of each one of these control methods and design an integrated control system which does the job that we have to accomplish. This is what we are looking for.

We would like to mold together, as best we can, the various options we have available to us to accomplish this task, and we would like to have you people work with us as closely as possbile so that we can accomplish this. Thank you.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. Richard Koegel

I would like to discuss a few of the systems and gadgets we have been working on. We don't claim any of these as a panacea, but just as tools within the tool kit that harvesters may find useful in given situations.

One of our systems is on Buffalo Lake in central Wisconsin. Buffalo Lake is an impoundment and, just above it, a barricade was put in obliquely. This extends into the water about two feet to prevent any of the previously cut floating vegetation which finds its way down there from going over the dam.

We do have a stationary removal system. We are counting on current and prevailing winds to bring this cut material down out of the lake. The system foresaw five small cutters working in the lake, so the coverage capability would be about five acres per hour. The removal system was designed for about 50 tons per hour removal.

We realize that in many situations water currents or winds are not such that we can get material to a stationary removal point. So we have been working--doing some booming and netting. This net we have used with milfoil is equipped with some vertical stays that have floats at the top and weights at the bottom to keep the net vertical in the water, which keeps the top edge of the net above the water surface so the material doesn't tend to crawl over it.

We use a very small, simple conveyor. It was designed so that two men could move it around, as a small power unit which can be used with a little gasoline engine or an electric motor. It is based on double-chain with cross slats and fish netting over the cross slats, which makes a fairly light yet quite effective conveyor. We feel under ideal situations, if you could get the plant material to it, you could remove 20 tons an hour with such a small device.

We have adapted a device in front of a harvester to increase

harvesting rates. Two arms in V-configuration are used to triple the effective width of a conveyor. This presupposes that the material has been previously cut with fairly high-speed, small cutters. We come in with the harvester with this gathering device on it, bring the material into a fairly narrow swath, and then pick it up onto the harvester.

Then we have what you might call a set of wringer rolls. Material comes up an apron, which consists of steel rods--and this could be on a harvester or it could be on the shore--and the material is dumped onto it by means of some other conveyor. The material then feeds between a steel cage-type roll on the bottom and a rubber roll on the top. It is dewatered, compacted considerably, and then pinched into lengths by a third roll which has radial blades on the back. This has really a triple function device, dewatering, compacting, and cutting into easily handled lengths for moving about and transporting.

Finally, we have what we call a high-speed cutter, which is in the early stages of development. It would be mounted on pontoons and towed at fairly high speed through the water. It has got a rake angle, a cutting edge on the front. The inclined support would be clad with sheet metal. According to tests we have done in tanks and so forth, this should cut the material as it is towed through the water at reasonably high speed, by which we would probably mean on the order of three to five miles per hour. Thank you.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Charles Hummer

Actually, for our problem, we are not doing any cutting as such.

We are using current flow and wind action. Our primary problem is the Chagres River, right before it enters into the main channel of the Canal. Our primary problem here is keeping the weeds out of the Canal. We have a diversion boom extending across and angular to the flow of the current.

As the material comes to us, it is diverted into a holding lagoon. We do get masses coming down, and we try to stimulate this when we want it to come down, rather than during the flood season. We use chemicals to cut it, and we use control flushing through the upper dam to induce the current.

As it floats down into this lagoon, we have a slack line mounted on the top, a cableway with a rake. This picks up four tons at a time. When you are really working hard, you can get as much as one cycle per minute. Normally we will get about one cycle every two minutes.

We have confining booms to compress the material to bring it into the cableway and this requires two motorized boats and a little submarine that we have had since 1875, a little diesel-powered launch.

By using a series of confining booms we just keep swinging these in until we have cleared the area. Then we swing them all back out again in an array.

As I said, this is the largest harvesting operation that we have ongoing. We do have other areas where we pick up basically hyacinth, although we do pick up an awful lot of hydrilla with this system and the drift.

We have other major rivers running into the Canal, although not as large as the Chagres, on which we have confining booms. This isn't a new idea; in 1931 they had the same device. We have only bought newer equipment. It has been extremely successful for a number of years.

On the more remote locations, we have a barge, which we also got in 1875, with a double-drum winch. We go into an area once the material has accumulated behind the booms. We have a very "sophisticated" system of putting a snatch block up against the closest tree, if we have one; we use a steel cargo net and drag it up on shore.

If the mass is too large, we use another very sophisticated system, two men in a boat with machetes who cut it into proper sizes. As you might imagine, this is a rather laborious and unrewarding task for those who are doing it.

The third and most unrewarding way we do this is using pitchforks. This is an area where we have an awful lot of drift coming down. At times of the year we do have a lot of hyacinth coming into some of these locations, which we can't get the cable boat into. So we go to the most basic manpower around, two men with pitchforks.

To give you an idea of the amounts of material we are removing by the various means that I have just mentioned--with the cableway we are moving about 27,000 tons a year off the Chagres. We peaked in '74 at 47,000 tons a year. This year has been fairly good. We have removed 65,000 tons, total. About half of our work is done manually; the rest is done with the cableway.

To give you an idea of what the costs are, we are estimating that the cableway, in '76 dollars, runs us about a dollar a ton. We estimate about 120 tons per acre, so that will give you the approximate cost of that. We remove about 120 tons a day, using the cableway.

The cable boat runs about \$3 an hour with the associated people, and the manual, of course, goes up considerably higher, ten orders of magnitude over the cableway, which one would expect.

In order to put this into proper perspective, we may be far away, but we pay U. S. wages to all those folks in the rowboats, minimum wage, about \$2 to \$3 an hour. The operator of the cableway makes about \$10 an hour, so it isn't cheap, laborwise.

I have to agree with one of the previous speakers. I think one of the real questions in making mechanical control a more viable option is, what do you do with all of this garbage once you get it on the bank?

We have a pile there, collecting 47,000 tons a year, wet weight, over a period of four years, and I tell you, that is an awful lot of stuff and it smells bad!

We have tried some really interesting things to get rid of it that I would like to share with you very shortly. I can recommend that you don't try them. We tried to burn it. I pumped as much as 200 barrels into that pile and it gobbled up the oil, but it didn't burn.

Then my boss said to dynamite it. We went out and drilled holes in it, and we loaded 20 cases of 60 percent ammonium gel dynamite. We set it off, and all it did was just sort of go "whoosh." A geyser of this stuff blew into the air and over the hill where we were standing with the detonator, and we smelled like we came out of a pig yard when we got out of there.

We finally did the only thing that was left to us. We put a D-8 'dozer on it and 'dozed it out flat, which was very successful. We do that about every three years now.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Dr. Larry Bagnall

I have a plaque on my wall in the office, a quotation from Emerson, which states that a weed is a plant whose virtues have not been discovered. In many cases, virtue and vice are a matter of opinion, but I regard myself somewhat in the business of discovering virtues or at least characteristics of some of these materials we are working with.

One of the things similar to what you saw yesterday is the use of waterhyacinth for the recovery of nutrients from municipal waste waters. One operation is in Plant City, Florida, where they are tertiary-treating to Florida State standards four million gallons a day in a 15-acre pond. They harvest somewhat irregularly. They could probably improve their performance by a more systematic harvest.

In another place, Zellwood, hyacinth are being used experimentally for removal of nutrients from irrigation return flows.

In Thailand this spring we saw the use of the waterhyacinth in a fisheries resource, where they use these to support their fisheries by attracting fish to feast on the "creepy-crawlies." They get fat and then get trapped, and ultimately end up as a major protein source in that developing country.

The interface between where they are in the water and where we get them for some sort of utilization is the harvester.

We consider the harvesting problem, and much of the other problem associated with it, as a materials handling problem. How can we economically get the plants from Point A someplace out in the water to Point B someplace where we no longer have to put any additional inputs into moving them? Then, ultimately, what must be done to improve the economy of this operation?

We think one obvious improvement is to eliminate manual labor. This might not be an improvement in the economy in some of the developing countries, but it certainly is in the economy of this country.

We see a need for increasing capacity. The two areas where we think that the greatest impact can be made in increasing capacity are improving the flow to the harvesting machinery and improving the flow away from the harvesting machinery. By and large, if this machinery could be properly fed and have the material properly removed, it would probably have a very large capacity.

The area in which we think we can make the greatest improvement in getting the material away from the harvester is in reducing the volume and increasing the fluidity of the harvested material.

What we have in mind is using a full-width set of crimping rolls. The plants flow through, and hopefully they are broken up to the point where they are very fluid and where the density increases a great deal. From there on we can handle them in relatively small conveying systems. We have some problems in handling materials with this particular machine. It is presently disassembled and the structure has been redesigned.

Another system harvests leaves for pig feed. This is a utilization which as an economic reality. They harvest the leaves alone, whereas we have been trying to feed the whole plant have run into some problems with palatability and nutrient utilization.

Another possible means of utilization is applying these to the land. We have got five plots, in ten tons per acre of hyacinth, 100 tons per acre of hyacinth, the control plot, ten tons per acre of hydrilla, and 100 tons per acre of hydrilla.

We planted these in August with rye, which, by the way, is not the right time to plant this in Florida. It came up about four weeks later. Since then we have had some dry days and most all of this has been burned off, except that on the 100-tons-per-acre of waterhyacinth, which had good water retention and sustained the crop even in a very difficult stress situation.

We can compost this material. After four weeks hydrilla had a 95 percent reduction in volume, simply by letting it sit there and decompose aerobically. With the box of waterhyacinth, we got a 46 percent reduction in volume. The hydrilla at the same time had a 77 percent mass reduction and the hyacinth had a 55 percent mass reduction. Simply

by allowing it to sit, we can minimize the amount of material that we have to remove. Conceivably we could do this very close to the harvesting site.

Composted waterhyacinth has been used as a growth medium for mushrooms in Thailand. We have in development a chopper for reduction of the volume. We have found that commercial choppers can do this. We can get approximately between a 67 percent and a 90 percent reduction in volume by chopping, destroying the structure of the plants. If we can do this immediately after harvesting, we can increase the capacity of our handling systems throughout.

We have done some test work on the utilization of both hyacinth and hydrilla for silage for animal feed. We did some work about a year ago with hydrilla for ensiled cattle feed. In four siloes we stuffed, I believe, about seven truckloads. The volume reduction through this system is fairly substantial. We used a chopper followed by a screw press. We have built a number of experimental presses. We have used a small four-inch press for some of our laboratory lots of material that will handle about 100 kilograms an hour, maybe a little more. We also have an intermediate size press, eight-inch, which will handle approximately three or four tons an hour.

We have also done some work with solar drying, and we think that we have a capability with it. We certainly do not have a capability in terms of drying with gas or fuel oil. We did some work on that, about six years ago, and at that time the cost of the fuel was marginal. Of course, the costs of fuel since then have gone completely out of sight, so we are going back and looking at solar drying.

The main problem with the solar drying is the amount of area that you need to do a good job in a reasonable amount of time, to get it dry before it decomposes.

Something was said a little while ago about putting 50 percent or 20 percent of the material back in the water. This would really make it go, I think, and I don't think we want it back there.

We have done some work with the juice, adjustment of the pH and centrifuging the solids from it.

We have a few products here. We have some waterhyacinth silage, which is a year old and still in pretty good condition. The hydrilla silage, however, is not in very good condition. Some of the feed materials we have made include hydrilla meal and pressed and dehydrated waterhyacinth--waterhyacinth pellets, which somebody mentioned about putting them in the water and letting them sink. These will do that very nicely.

We have got some juice solids. In one demonstration that I had last spring, we made some cookies out of these. Then there are some juice screenings, which are essentially very similar material.

That's it. Thank you.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Tomas Kelpin

In 1962 when I first became obsessed with weed harvesting, I discovered Matt Grinwald had a 100-cubic-foot harvester with a 30-horsepower engine and a cutting width of six feet down to three feet. He harvested 1000 pounds of weed and marketed that machine for about $20,000. His propulsion was paddle-wheels and outboards, the outboard being on the transport barge.

Between '62 and '64 Matt Grinwald went into partnership with Howard Stern and they increased the carrying capacity to about 300 cubic feet. They increased the horsepower by six, making a total of 36 horse. They brought the width up to about eight feet, and they decided they had better go down to about four. The total carrying capacity was about 3000 pounds. Again, it was paddle-wheels on the harvester and outboards on the transport barge. Their selling price was about $28,000.

In '65 those two, and then myself and Jerry Just, brought up the capacity to 400 cubic feet, kept our horsepower range about the same, the harvesting width the same at eight feet, and we went down to five feet. Our overall carrying capacity was about 4000 pounds. We marketed between 10 and 15 of these machines all over, at about $30,000.

In '66 Matt Grinwald left Howard Sterns, and Jerry Just and myself, working for Howard, increased the capacity in cubic feet to about 600. We went from 36 horsepower up to 150 horsepower. We kept our cutting width the same at eight feet, five-foot depth, and we had a carrying capacity of about 6000 pounds. We were getting about $36,000 for those machines. Two or three of them are in Florida, but they are up on blocks now.

In '68 we jumped up to 800 cubic foot, again Jerry Just, Howard Sterns, and myself. We increased our horsepower to 200. We went to a 10-foot swath, five-foot deep, and 8000 pounds carrying capacity, and a cost range of $39,000 to $42,000.

In '69 we managed to get up to 1000 cubic feet. Our horsepower went up to 350, with 12-foot swath, six-foot deep, harvested about 10,000 pounds. This was a single machine, and it is in Zorita, Spain. It sold in the $70,000 classification.

Then the whole thing just went down. So, being obsessed with the project, I went ahead and developed a machine that had 2000 cubic foot carrying capacity and around 200 horsepower. John Neill is presently harvesting with that machine, but he added better flotation, and his carrying capacity is about 20,000 pounds.

We went from paddle-wheels to outboards, then to outdrives, and then I came along with air. My partner, Glen Carver, and his brother Randolph, are presently working with a 12-foot-wide machine. They are considering blanching, putting right back into the water. They are in lab-testing now.

We are not going to use air, we are not going to use paddle-wheels, and if I learned one thing since moving down South, I have learned that the design of a mudboat is something so superior that I don't know why I have never seen it before.

That is where we stand, besides changing the name from Carver Aquatics to Carver International. Thank you.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Harry McGill

About a year ago we were faced with what turned out to be a rather unusual situation in a potable water supply canal in Port Charlotte. We had, I had roughly estimated, about a 200 percent infestation of aquatic weeds. That sounds ridiculous, of course, but we had what at one time was 100 percent infestation of hydrilla that had become overlain by waterhyacinths.

Being a potable water supply, we were severely limited as to what kinds of herbicides could be used, so we allowed the hyacinth to shade out the hydrilla and then harvested by dragline.

We had several choices. By this time some herbicides had been developed and labeled for use in potable water, but by my unique treatment system I had managed to successfully eliminate that particular method of treatment. In addition, the infestation was immediately adjacent to the primary water plant intake, so the president of General Development Utilities was not particularly pleased by the prospect of having herbicides introduced to his potable water supply.

As it turned out, the Corps of Engineers was finishing their project of last year, and there was a piece of equipment available to us. At that time I had never been involved with any type of aquatic weed harvesting.

It was something that we had spoken of in Aquatic Plant Society meetings, but I was unimpressed. Now I had a situation where this was obviously the method of choice. I felt that anything we did, regardless of how much it cost, was the way to clear this waterway.

About halfway through our first project it began to dawn on me that this really wasn't so bad. It really wasn't that costly. I was looking at this in terms that we were indeed paying him $300 a day lease on equipment. We were paying our own salaries. We were driving our own

trucks and spending our own money on it. I figured that this was costing us $350 an acre.

But in reality, had I owned that machine, had we not been paying a very large lease, figuring that even if we could operate this particular machine at 100 days a year, our cost would have come down to $236 an acre.

This was seemingly high, but in this particular area we had already said that the treatment cost for hydrilla was going to be approximately $200, probably slightly more. This was because we would have used one of the more expensive materials to treat it, being one of the few with potable water labels for hydrilla treatment.

Our cost then, in reality, instead of being $200, probably would have been somewhere in the range of $210 to $215 to treat this adequately. Plus, we would have had the problem of dealing with an irate public, because we were spraying "poisons" in their potable water supply. Probably through our treatment system and treatment of the influent water with activated carbon, we could have avoided any possibility of having these materials in the water supply. We would also have dealt with odors and tastes.

The real crux of it, though, is that the difference between harvesting and the chemical treatment is not particularly significant. We have something now that is acceptable to us, because we have done something positive. We have made an effort to control the aquatic vegetation in these canals.

It has been six months or longer since the completion of that project, and it is now time to decide whether we are going to do it again. This time I look for the treatment to be less expensive with the chemicals--because we don't have the waterhyacinth problem, since they haven't come back--and with the harvest, because the machines are more effective when harvesting hydrilla.

We figure for the next time, operating the same way that we did, the harvesting costs would probably come down to about $172 per acre, and that is eminently acceptable to us.

Also, when we moved from this area, we put the harvester into a

third series of canals and lakes in Port Charlotte that were 100 percent infested with hydrilla. This time, what we were doing, more or less, was trying to stall off the public. We didn't want them on our back any more. We wanted to have some type of solution that would make them happy.

So,--here again, our decision was to harvest this at any cost. But when we finished and we did all our calculations, we came up with a treatment cost for this particular area of about $174 an acre. This meant that for this one treatment, this one harvest, we actually were able to go in and remove the aqautic vegetation from this one series of canals, which I will admit was a very good worksite, and in this instance we are satisfied that we have actually saved money with our harvest project.

We responded to several questions when we initiated the project. Will we in effect be aggravating the situation that we have by fragmentation? Will we be spreading? Will the material come back thicker than it did before?

It has been our experience that after this harvest, where we harvested an extremely heavy growth, we have come back in and maintained these areas relatively inexpensively with herbicides, making about half the frequency, or increasing the length by our treatments by one-half. So instead of making a third treatment this coming year, it appears that we will be making one to follow up the harvest work.

I would have to say that to me this was quite a revelation. I have never been involved with this. I had never gotten even casually acquainted with harvesting up until these projects began, and I think that I could be a convert.

I think that if we were to go through some of the work that the Corps of Engineers is doing, realizing that at this time much of the work they are doing is quite expensive because they are paying an organization to contract the work--I set up the contract and negotiated it as well as I could, and I think we came up with an eminently fair contract.

I think that the work on Orange Lake is acceptable. But I hope that when we get through, we can sit down and say to the Corps of

Engineers, if you owned this equipment or if an individual owned this equipment, and you didn't have to pay a lease or you weren't paying somebody's profit, then you could in reality be making money with your harvest work on Orange Lake.

Thank you.

PANEL DISCUSSION
MECHANICAL CONTROL TECHNOLOGY DEVELOPMENT

by

Howard Grisham

Some of you might wonder why the Astor Kiwanis Club would ever get involved in aquatic weed control on the St. Johns River. I will tell you very frankly, it was a matter of life or death. In plain words, self-survival for the people that use the river for their livelihood, to maintain and keep their families and to raise them in what we have in this country.

Many of the people on the St. Johns River had invested all that they had in their little businesses, and our Kiwanis Club became concerned about that.

We decided to get into a program, "Help Stop the Killing of the St. Johns River," and that consists of three S's. I will briefly touch on those. One of them is the spraying of hyacinths by chemicals. They are killing them, sinking them to the bottom, causing very damaging pollution, and also killing the spawning grounds of the St. Johns River.

Secondly is the dumping of sewage effluent into St. Johns River by the various municipalities and others.

Third of the S's is the siphoning of water to the south and east, reducing our current to the north. If we could get our current back in the river, maybe these boys could get in and do a little cheaper job of harvesting.

I want to say this. If there is any state in this Union that needs a change in aquatic weed control, it is Florida. A fine example of that is some of the figures that you have heard at this meeting. This last year, 1976, it cost the state of Florida $20 million in aquatic weed control. We were told in ten years it is going to cost us $100 million.

In 1958 or 1960--I've heard both dates--hydrilla was introduced into the state of Florida. This year we have 200,000 acres of topped out hydrilla and 500,000 acres of rooted hydrilla. In my opinion, we

have done very little control. We have primarily used chemical control. What we have been doing in our chemical control is helping to destroy the third largest industry in Florida. That is fishing.

You people might not be concerned. I have heard hardly a word about what you are doing to the fisheries. I don't believe there has been a word in this conference. But let me tell you, in Florida we are interested in fisheries. If we kill our fisheries, we are dead. Did you ever stop to think how much money is spent each year to catch these fish?

We know in Florida that more money is spent to catch the one fish, the largemouth black bass, than any other fish in all the world. We know that we cannot afford to destroy our third largest industry, and that is what we have been doing in the methods of control of aquatic plants in Florida.

One of the greatest problems in Florida is that we have got so many people in the aqautic weed control business that we really don't know what in the world we are doing. We are just doing it. We are not looking at the end results. We are just out there taking care of what we can see.

Let me try to give you an example. In Kissimmee there is a lake, Tohopekaliga. $600,000 was spent to drain that lake because, with Orlando dumping sewage effluent in there by 17 million gallons a day, and then others dumping it in, there was a hyacinth problem. Those hyacinths were being fed so rapidly with fertilizer that they just outgrew any means of control. So they went out and sprayed them and sank them to the bottom.

The next thing you know, they said we must draw this lake down so we can put our fisheries back in it. They did it. Again, let me repeat, almost $600,000. It came back.

I have been in that lake many times. I have caught my largest black bass there. I have seen the misuse and abuse by these various agencies in the state of Florida of the controls we are using. I have seen the airboats out there in winds proven to be over 20 miles an hour,

spraying the chemical 2,4-D, when the law says that they should not be there.

This is our control problem. This is the problem of the chemical people. The people out there doing the job, the people supervising the job, are not doing what they are supposed to be doing.

If we had spent as much money in Florida on mechanical harvesting properly, I don't believe that we would have the hydrilla where it is and I don't believe the water quality in many of our streams would be as low as it is today.

We built some machines, but I want to say this about the machines. To operate one of those machines that the state of Florida built, it cost $48,000 for two hours. I don't call this a harvester. I just call it a monstrosity, a monstrosity where we spent our money really for nothing.

I could talk for hours on the problems in Florida. I would only hope that the people that have the money and the means of reaching out put the money in the right places to research harvesting and spend not as much as you are on other things, particularly the white amur, the fish. I'm not going to bank on anything I have no control over.

If we would spend just a little bit of that money that we are spending on other things and research, and put it into mechanical harvesting, I belive that our fisheries in Florida would not be on the decline that they are today.

In 1971 the Game and Fresh Water Fish Commission in Florida made a survey of the St. Johns River. $10 million was lost in fisheries on the St. Johns River alone. Four years later that loss ran to $25 million.

If we take the costs that I have heard here, cost of applying herbicides, and add the destruction that the plants cause by sinking to the bottom and decaying in their natural process of decaying--and we have a lot of waters in Florida that are full of suspended fibers of waterhyacinths, bonnets and others, where they have shot the chemicals on them, not paying attention to what they were doing.

We are talking about spending a lot of money to draw these down,

but if we take this money that we have spent, that we are losing, and add it to the mechanical harvesting costs that we all pay, it costs so much that we can't do it. But if we take the costs of this $10 million and $25 million and add it to the spray costs, then we are going to get the scale to go the other way. The chemical is going to be way out of sight.

Let's put the hyacinth to work like you saw yesterday, harvest it, pick it and its nutrients out of the water. There we will be doing a complete job. We won't be trying to take the place of nature; we will be assisting nature. We will be creating a balance in our waters in Florida and other places, and there we will be able to put back the fisheries and we will have productive live waters.

Thank you very much.

MEETING SYNOPSIS

by

W. G. Shockley

I would first like to update the statistics on the attendance at this meeting. There are seven of the Corps of Engineer Divisions represented, either through direct representation or through district representation. This is over half of the divisions in the Corps of Engineers, and I think this is a fine representation, in addition to the 17 districts that are represented. Twenty-three states are represented. Four overseas entities are represented. Twenty-eight state, local, and private agencies are represented.

The enthusiastic attendance at this meeting I think speaks well for the interest in this very pressing problem that is affecting many parts of our country.

We have heard a lot of things in the last three days, and to use some of the buzzwords that have come out of the conference, we have many "challenges" still facing us. We have many "opportunities" for trying new things, for applying the technology that comes out of the research programs, not only from our organization but from other organizations who are engaged in research in this area.

It is evident from the presentations made at this meeting that progress is indeed being made in many areas of research. In particular I can mention the upthrust of mechanical harvesting that we have just heard about. Three years ago in Charleston this was hardly mentioned, and here we have a whole panel devoted to this one subject and people working in the field, in the laboratories, in industry, developing areas of mechanical harvesting.

We are beginning to recognize the need to plan ahead to solve problems in aquatic plant control. I am talking particularly in the Corps area now, although I realize that the states are faced with this problem, too.

We have to go carefully through the regulatory requirements in

order to get our job done. We need to have definite information on the field situation, the degrees of infestation, the kinds of things that need to be controlled, before we can plan properly for this, and we are working in this direction.

We are beginning to recognize deficiencies in the process. We need to improve the processes in the Corps, at least, so that we can easily take preventative measures to get at some of these problems before they become real problems, to start controlling things before they get out of hand. This needs to be done perhaps through changes in regulations, perhaps through more initiative on the part of the District people, but it needs to be looked at and solutions arrived at.

Again, I am addressing Corps people. In order for research to go in proper directions, you people in the District offices of the Corps need to state your problems through the mission problem statements so there is something in writing with which the people in the Chief of Engineers' office in Washington can justify spending the research dollars.

They are not going to send one dollar to the Waterways Experiment Station or any place else if the Districts say we have got no problem. They are going to cut that research off because there are plenty of other places they can spend dollars. You have to state those problems. You have to tell your people in Washington about them. This is something that I cannot emphasize too much.

We need improvement in regulations, and we also need new materials. We need safer materials. Much was said about this during this conference. We need more joint efforts of federal, state, industry, and the local people working together to help solve these problems. It is beginning to work in some of these areas, but more can be done and needs to be done.

We are also finding a few things about the ecological balances. I presume the life sciences people knew this all along. We poor engineers don't know about these fancy things. We have heard that nature abhors a vacuum. If you get rid of one plant, something else is going

to come in and take the place. We don't know too much about that. We need to know more about it.

This is an area that needs a lot of exploration to find out if, in controlling these troublesome plants, we are going to end up with something worse than what we started with and something we wish we hadn't done. We have to be very careful in doing this sort of thing.

We had a lot of discussion on the white amur fish, still somewhat controversial. We are now beginning to get some definite information from the Lake Conway studies, from some of these other studies that the states are carrying on, that begin to give us numbers, quantities, effects, results. Hopefully, in our studies several years from now we will be able to get up in a meeting like this and give you some real answers on some of the problems that still plague us in the use of this fish to control aquatic plants.

We see some states such as Arkansas that are completely enthusiastic, consider the fish as an operational management tool that they use every day. Other people in other states are very cautious and they are not willing to accept this yet. I don't know where the answer lies but I hope that the research in the next few years will give us some of these answers.

In the mechanical harvesting area much was said about the use of aquatic plants as resources. This is a natural outgrowth. When you spray an aquatic plant with chemicals, it wilts away, it dies, it goes some place else. When you use mechanical harvesting, you have got a mess on your hands that you have got to do something with.

Why not take advantage of this opportunity and consider the product of mechanical harvesting as a resource and find ways of utilizing the materials. Lots of good things have been said about it, but I think it comes down to the marketplace, the economics. Who is going to put money into the use of these things and turn a profit, because that is what it is all about when you talk about using the aquatic plants as resources. It is something that needs to be looked at, and thank goodness, a number of people are indeed looking in this area.

I do have one thing that I would like to say to the group here.

This is probably the last time that I will address this group. We have been given notice at our Experiment Station that we are to reorganize during the coming year. Our laboratory will be abolished and the aquatic plant research group is going to be moved to another laboratory. At this time we have no indication as to whether they will remain as the group that they are. I do not know what kind of direction they will have, whether it will be the same direction or not, although I realize that the basic direction comes from the Chief of Engineers' office in Washington, but there will be a new ball game next year, and there may be some changes.

I hope that the group that has been working together so well for the last couple of years will continue to work and our directions will continue to be pretty much the same.

APPENDIX A: EXECUTIVE SUMMARY OF 12th ANNUAL AQUATIC PLANT CONTROL RESEARCH PLANNING MEETING

The Corps' Aquatic Plant Control Program is authorized under Section 302, Public Law 89-298 (79 Stat. 1092), Rivers and Harbors Act of 1965. The program is carried out under Engineering Regulation ER 1130-2-412 dated 28 May 1976. The program consists of operations activities which are the responsibility of the various Engineer District offices and research conducted by the USAE Waterways Experiment Station under the Aquatic Plant Control Research Program (APCRP). The APCRP conducts technology development and transfer through six APCRP elements:

I	Biological Control Technology
II	Chemical Control Technology
III	Mechanical Control Technology
IV	Integrated Control Technology
V	Problem Identification and Assessment
VI	Management Technology

The existing ER 1130-2-412 requires that a research planning meeting be held each year to provide for professional presentation of current research projects, review of current operations activities, and review of the research proposals. This document is intended to summarize the current research projects, operational activities, and overall research needs identified as the result of the 12th Annual APCRP Meeting. This meeting was held on 3-6 October 1977 in New Orleans, Louisiana.

Current research projects

The following research is currently being conducted for control of various problem plants and was reviewed at the planning meeting:

1. Biological Control Technology - Six research projects for the development of insect and pathogen control agents.
2. Chemical Control Technology - Six research projects for the development of chemical control agents and application techniques.
3. Mechanical Control Technology - Three research projects for the development of mechanical control methods.

4. Integrated Control Technology - Three research projects for the development of control methods that utilize combinations of methods.

5. Problem Identification and Assessment - Two research projects for the development of methods for assessing the scope of the problem and determining the economics of aquatic plant control.

6. Management Technology - Three research projects for the development of management techniques for planning plant control operations. This includes predictive capabilities in all technology areas. In addition, the Large Scale Operations Management Test Using the White Amur (a technology transfer project) was reviewed.

Current operational activities

At the meeting there were 9 Corps of Engineer Division offices and 18 Corps of Engineer District offices represented as well as OCE and WES personnel. Representatives of each Engineer District present summarized their current operational activities in aquatic plant control. Generally, these activities ranged from full-scale successful maintenance programs to no activity, although major problems are presently recognized. In addition to these district presentations, reviews were presented by the majority of the 32 state, local, and private agencies represented. In all, 23 states and 4 overseas entities were represented.

The following summarizes the primary problem plants and relevant economic data identified by participants during the research planning meeting:

Emergent

Waterhyacinth

Alligatorweed

Submersed

Eurasian watermilfoil

Hydrilla

Egeria

Collectively, it was reported that the above problem plants combine to infest between 950,000-1,250,000 acres of water surface in Florida, Texas, Louisiana, Georgia, and Oklahoma. A total of $27,150,000 was reported spent for control during the last 18 months in an effort to minimize an economic loss to recreation, navigation, and water production estimated at $200,000,000 during the same period.

New research identified

The following is a list of immediate research needs identified as a result of presentations and discussions conducted at the meeting:

1. A system of monitoring operational areas on a regular basis that is uniform throughout the Corps.
2. A problem classification system that provides a basis for optimizing control stragegies.
3. Capability to predict where outbreaks of problem plants are likely to occur.
4. A more accelerated method of identifying problems to research.
5. An active continuous program of problem prevention and maintenance.
6. Aquatic plant management strategies for each major reservoir project that can be integrated into resource management plans.
7. Basic training seminars for reservoir rangers that would enable them to identify problem aquatic plant species.
8. Better technology transfer to the general public.
9. Better on-the-shelf availability of biological agents.
10. A better understanding of life cycles of major problem plants, resulting in summary booklets for Engineer Districts APC management personnel that clearly present these life cycles and their relationships to plant control.
11. Methods for economical use of aquatic plants.
12. Better management systems for maintaining and supplying available biocontrol agents already cleared for use by USDA.
13. More cooperative testing efforts between Corps and chemical companies, including more freedom of exchange of data required to obtain experimental use permits. Accelerate required data collection.
14. Better guidance on chemical application rates as a function of water quality conditions.
15. Improved chemical application techniques.

These items are presently being addressed in varying degrees in the current APCRP as outlined in the approved 5-year plan. As new mission problems are identified by the user, these will be integrated into the program and addressed as funds permit, keeping technology transfer as the primary overall objective.

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

United States. Waterways Experiment Station, Vicksburg, Miss.
Proceedings, Research Planning Conference on the Aquatic Plant Control Program, 3-6 October 1977, New Orleans, La. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.
xxx, 243, [4] p. ; 27 cm. (Miscellaneous paper - U. S. Army Engineer Waterways Experiment Station ; A-78-1)
Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C.

1. Aquatic plant control -- Congresses. 2. Research planning -- Congresses. I. United States. Army. Corps of Engineers. II. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; A-78-1.
TA7.W34m no.A-78-1